Models 172, 173
Instruction Manual

Contains Operating and Servicing/Calibration Information for Models 172, 173, 1722, and 1728

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MASTER

INSTRUCTION MANUAL

Digital Multimeter

Models 172, 173

[Contains Operating and Servicing/Calibration Information For Models 172, 173, 1722, and 1728.]

KEITHLEY INSTRUMENTS

INSTRUCTION MANUAL

Digital Multimeter

Models 172, 173

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ILLUSTRATIONS

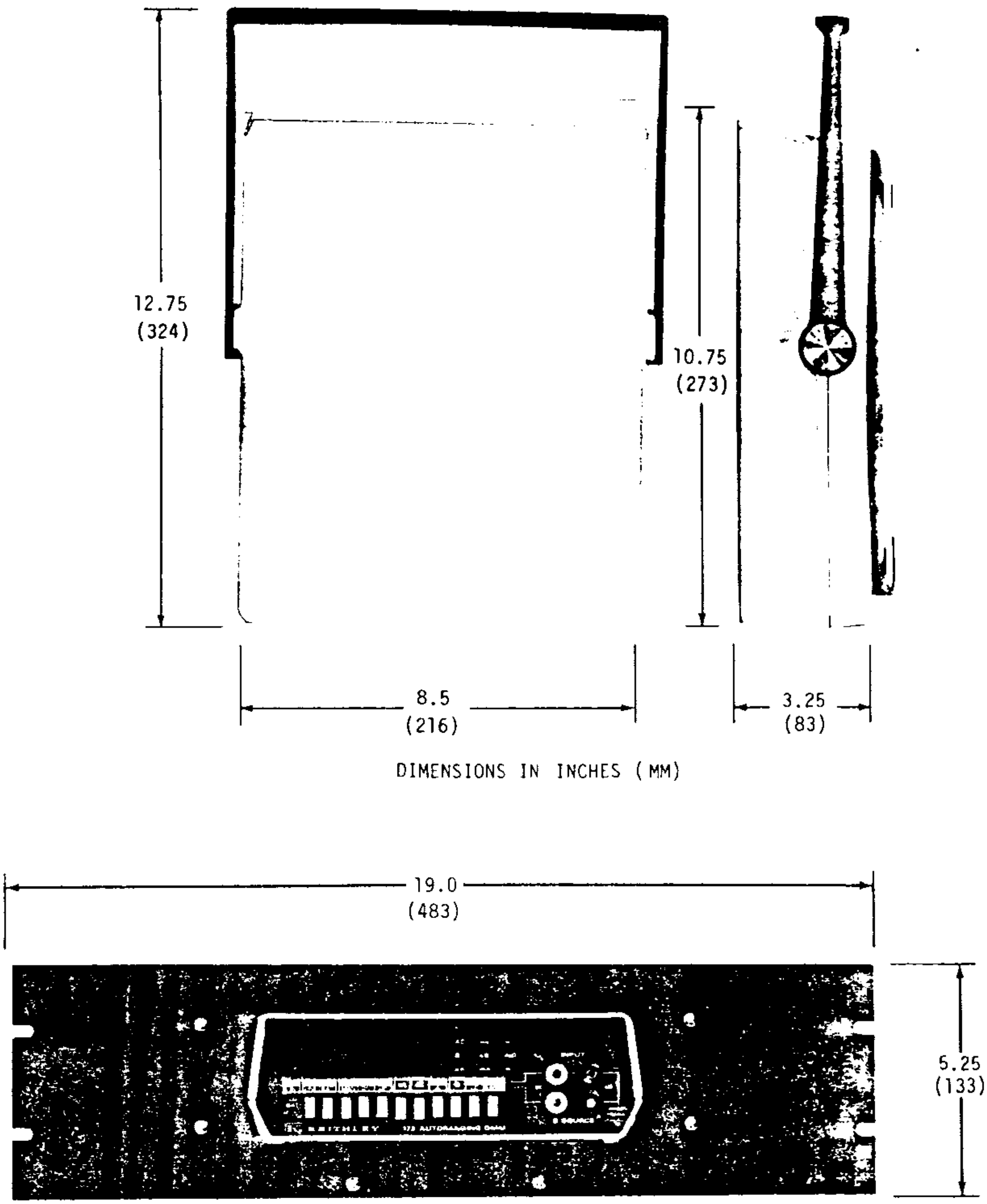


FIGURE 1. Dimensional Data.

SPECIFICATIONS

AS AN AUTO/MANUAL RANGING DC VOLTMETER

Calibrated at 25°C ± 1°C

RANGE	MAXIMUM READING	ACCURACY [±(% of rdg + digits)] (24h, 25° ± 1°C)	(6 months, 20°-30°C)	(1 year, 20°-30°C)	TEMPERATURE COEFFICIENT (0-20°C and 30°-55°C) ±(% of rdg + digits)/°C	INPUT RESISTANCE	MAXIMUM ALLOWABLE INPUT
300mV	299.99	0.009% + 1d	0.013% + 1d	0.015% + 1d	0.001 % + 0.1d	>1000M Ω	1200V peak*
3 V	2.9999	0.006% + 1d	0.013% + 1d	0.015% + 1d	0.001 % + 0.1d	>1000M Ω	1200V peak*
30 V	29.999	0.009% + 1d	0.013% + 1d	0.015% + 1d	0.0015% + 0.1d	10M Ω	1200V peak
300 V	299.99	0.009% + 1d	0.013% + 1d	0.015% + 1d	0.0015% + 0.1d	10M Ω	1200V peak
1000 V	1200.0	0.009% + 1d	0.013% + 1d	0.015% + 1d	0.0035% + 0.1d	10M Ω	1200V peak

*Overload on manual range not to exceed 600 volts continuous or 1200V for 3 seconds

NORMAL MODE REJECTION RATIO: Greater than 80dB over 1 digit at 50 & 60Hz, 70dB 50Hz to 10kHz

ANALOG SETTLING TIME (on-range): less than 0.3 second to within 0.01% of final reading

COMMON MODE REJECTION RATIO (1kΩ unbalance): Greater than 120dB at dc and 50 Hz to 10kHz

AS AN AUTO/MANUAL RANGING AC VOLTMETER

RANGE	READING MAXIMUM	ACCURACY* (1 year, 20°-30°C) ±(% of rdg + digits)	FREQUENCY RANGE	TEMPERATURE COEFFICIENT (0°-20°C and 30°-55°C) ±(% of rdg + digits)/°C
300mV	299.99	0.20% + 6d**	50Hz to 20kHz	.015% + 0.5d
3 V	2.9999	0.20% + 6d	50Hz to 20kHz	.015% + 0.5d
30 V	29.999	0.20% + 6d	50Hz to 20kHz	.015% + 0.5d
300 V	299.99	0.20% + 6d	50Hz to 20kHz	.015% + 0.5d
1000 V	1000.0	0.25% + 6d	50Hz to 10kHz	.02 % + 0.5d

Average responding calibrated in rms of a sine wave
*Above 70% relative humidity and 10kHz, add ±0.1% of rdg
**For readings below 1% of range, add 0.15 mV.

MAXIMUM ALLOWABLE INPUT: 1000V rms sine or dc, 10^7V·Hz maximum

ANALOG SETTLING TIME (on-range): less than 0.5 second to within 0.05% of final reading

INPUT IMPEDANCE: 2 megohms shunted by less than 50 picofarads

COMMON MODE REJECTION RATIO (1kΩ unbalance, Lo driven): Greater than 100dB at dc and 50 to 60Hz, decreasing to 70 dB at 10kHz

AS AN AUTO/MANUAL RANGING OHMMETER

RANGE	READING MAXIMUM	ACCURACY (1 year, 20°-30°C) ±(% of rdg + digits) HI	mode LO	MAXIMUM VOLTAGE ACROSS UNKNOWN ON RANGE* HI	mode LO	ALLOWABLE 4-T LEAD RESISTANCE	TEMPERATURE COEFFICIENT (0°-20°C and 30°-55°C) ±(% of rdg + digits)/°C HI	mode LO
300 Ω	299.99	—	0.035% + 1d	—	0.3V	1 Ω	—	0.003% + 0.1d
3k Ω	2.9999	0.035% + 1d	0.035% + 1d	3V	0.3V	10 Ω	0.003% + 0.1d	0.003% + 0.1d
30k Ω	29.999	0.035% + 1d	0.036% + 1d	3V	0.3V	100 Ω	0.003% + 0.1d	0.003% + 0.1d
300k Ω	299.99	0.035% + 1d	0.046% + 1d	3V	0.3V	100 Ω	0.003% + 0.1d	0.004% + 0.1d
3M Ω	2.9999	0.05 % + 1d	0.15 % + 1d	3V	0.3V	100 Ω	0.004% + 0.1d	0.02 % + 0.1d
30M Ω	29.999	0.18 % + 1d	0.8 % + 1d	3V	0.3V	100 Ω	0.02 % + 0.1d	0.15 % + 0.1d
300M Ω	299.99	1.5 % + 1d	—	3V	—	100 Ω	0.15 % + 0.1d	—

*Maximum open-circuit voltage, 5 volts

CONFIGURATION: 4-terminal or 2-terminal, switch selected.

MAXIMUM ALLOWABLE INPUT: 360V peak, 250V rms or dc.

ANALOG SETTLING TIME (on-range): Hi ohms below 10MΩ less than 0.4 second to within 0.01% of final reading. 10MΩ to 100MΩ and Lo ohms less than 1.7 seconds to within 0.01% of final reading

AS AN AUTO/MANUAL RANGING AC AND DC AMMETER

(MODEL 172 ONLY)

RANGE	MAXIMUM READING	DC ACCURACY (1 year, 20°-30°C) ±(% of rdg + digits)	AC ACCURACY (1 year, 20°-30°C) 50Hz-5kHz ±(% of rdg + digits)	INPUT RESIST-ANCE	FUSE PROTEC-TION
300mA	299.99	0.25% + 2d	0.5% + 18d	1.3 Ω	2A
2 A*	2.0000	0.25% + 2d	0.5% + 18d	1.3 Ω	2A

(MODEL 173 ONLY)

RANGE	MAXIMUM READING	DC ACCURACY (1 year, 20°-30°C) ±(% of rdg + digits)	AC ACCURACY (1 year, 20°-30°C) 50Hz-5kHz ±(% of rdg + digits)	INPUT RESIST-ANCE	FUSE PROTEC-TION
300μA	299.99	0.1% + 2d	0.3% + 18d	1k Ω	3A
3mA	2.9999	0.1% + 2d	0.3% + 18d	100 Ω	3A
30mA	29.999	0.1% + 2d	0.3% + 18d	10 Ω	3A
300mA	299.99	0.1% + 2d	0.3% + 18d	1.3 Ω	3A
3 A*	2.9999	0.1% + 2d	0.3% + 18d	0.4 Ω	3A

*Self-heating effects of currents greater than 1 ampere can double % of reading accuracy

TEMPERATURE COEFFICIENT (0°-20°C and 30°-55°C): DC: ± (0.005% of reading + 0.2 digits)/°C. AC: ± (0.03% of reading + 1 digit)/°C.

ANALOG SETTLING TIME (on-range): DC: less than 0.3 second to within 0.01% of final reading. AC: less than 0.5 second to within 0.05% of final reading.

GENERAL

ZERO STABILITY: Autozeroed to within accuracy specifications, 0°C-55°C.
DISPLAY: 4½ digits, appropriate decimal position, function and polarity indication. Three readings per second.
CONVERSION PERIOD: 320 milliseconds.
ISOLATION: Input LO to power line ground, greater than 1000 megohms shunted by approximately 300 picofarads. Maximum safe input between LO and power line ground, 1400 volts peak.
POLARITY: Automatic.
RANGING: Automatic or manual. Upranges at 30000, downranges at 02599.
OVERLOAD INDICATION: Blinks above ±1200V dc, 1000V ac. Blanks last four digits above 29999 counts on all other ranges.

ACCESSORIES AVAILABLE:
- ***Model 1728 Rechargeable Battery Pack.**
- ***Model 1722 Digital Interface.**
- **Model 1727 Mating Output Connector Set**
- ***Model 1723 IEEE Standard Bus Interface.**

*NOTE: Models 1722, 1723, and 1728 can only be installed and used one at a time.

SELF-CHECK: Rear-panel tip jacks give self-check of functional operation on 30-volt ac and dc ranges, 30kΩ ranges and 3mA ac and dc ranges.
WARMUP: 1 hour to rated accuracy.
ENVIRONMENT (without batteries installed):
Operating: 0°C to 55°C.
0% to 80% relative humidity up to 35°C.
Storage: −25°C to +65°C.
POWER: 105-125 or 210-250 volts (switch selected), 50-60Hz; 20V·A 90-110 volts available. Optional rechargeable 6-hour battery pack.
CONNECTORS: Input: Banana jacks. Self-check: Tip jacks.
DIMENSIONS, WEIGHT: 85 mm high x 235 mm wide x 275 mm deep (3½ in. x 9¼ in. x 10¾ in.). Net weight, exclusive of batteries, 2.3 kg (5 lbs.).

ACCESSORIES AVAILABLE: (Continued)
- **Model 1010 Single Rack Mounting Kit**
- **Model 1017 Dual Rack Mounting Kit**
- **Model 1600 High Voltage Probe**
- **Model 1725 Maintenance Kit.**
- **Model 1681 Clip-on Test Lead Set**
- **Model 1682 RF Probe**
- **Model 1683 Universal Test Lead Kit**

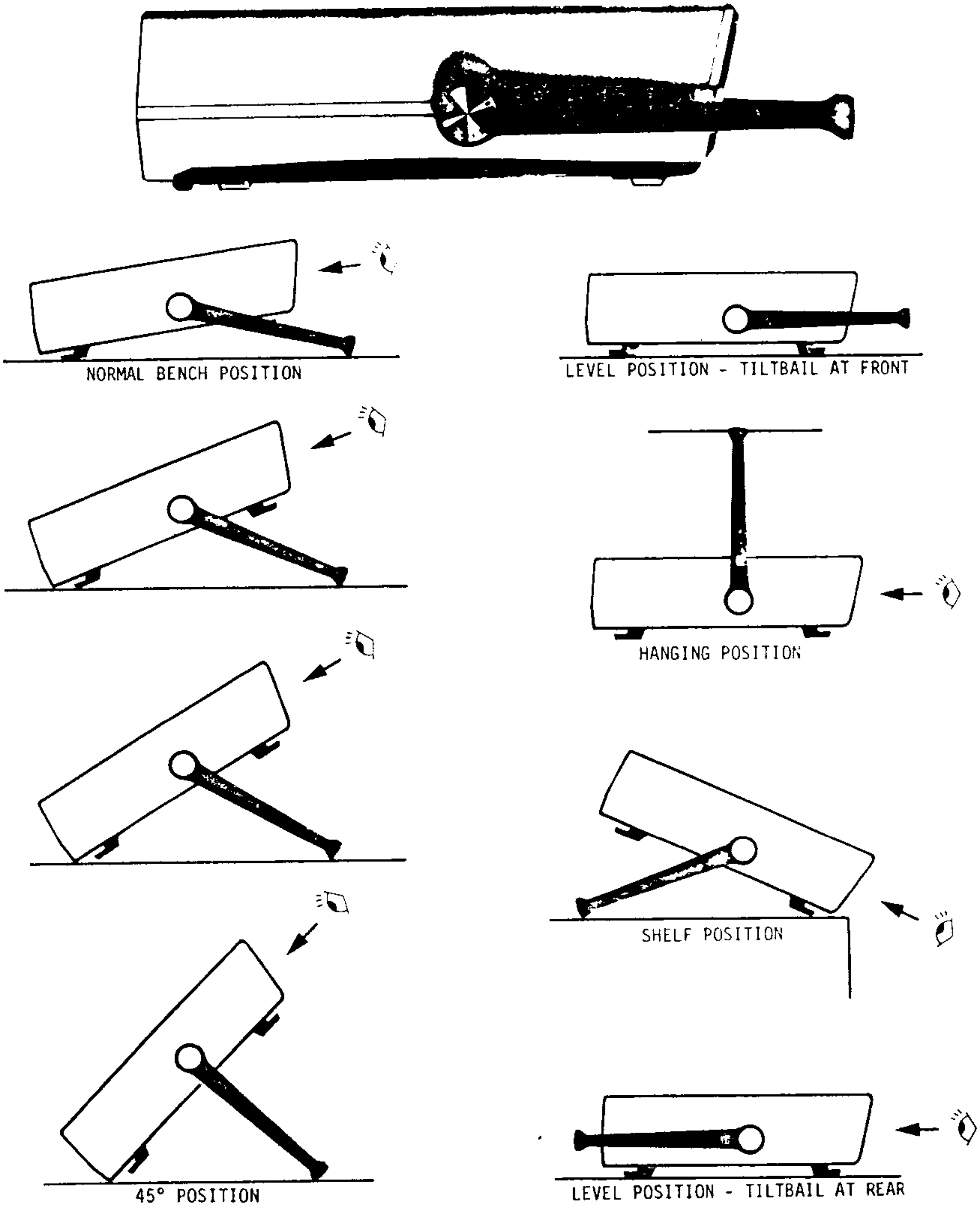


FIGURE 2. Tilt Bail Positions.

SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION. The Models 172 and 173 Digital Multimeters are wide-range, general-purpose measuring instruments, capable of measuring ac/dc voltage, ac/dc current, and resistance.

1-2. FEATURES

a. Automatic Ranging and Polarity

b. Manual Range Selection and Range Hold

c. HI and LO Ohms Capability

d. Line Operation

e. Optional Battery Operation, Model 1728.

f. Floating Capability to ±1400V peak

g. Optional Isolated Digital Interface, Model 1722.

1-3. WARRANTY INFORMATION. The warranty is stated on the inside front cover of the manual. If there is a need for service, contact your Keithley representative or authorized repair facility as given in our catalog.

1-4. CHANGE NOTICE. Improvements or changes to the instrument not incorporated into the manual will be explained on a change notice sheet attached to the inside back cover of the manual.

1-5. OPTIONAL MODEL 1728 RECHARGEABLE BATTERY PACK. The Model 1728 is an accessory battery pack which enables either line or battery operation. The Model 1728 has built-in recharging circuitry. The Model 1728 is field-installed on the Model 172/173 chasis.

1-6. OPTIONAL MODEL 1722 DIGITAL INTERFACE. The model 1722 is a field-installable digital output option. It provides isolated open-collector BCD outputs and control lines.

IMPORTANT

The ⚠ symbol can be found in various places in this Instruction Manual. Carefully read the associated *CAUTION* statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

The ⚡ symbol can be found in various places in this Instruction Manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated *WARNING* statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

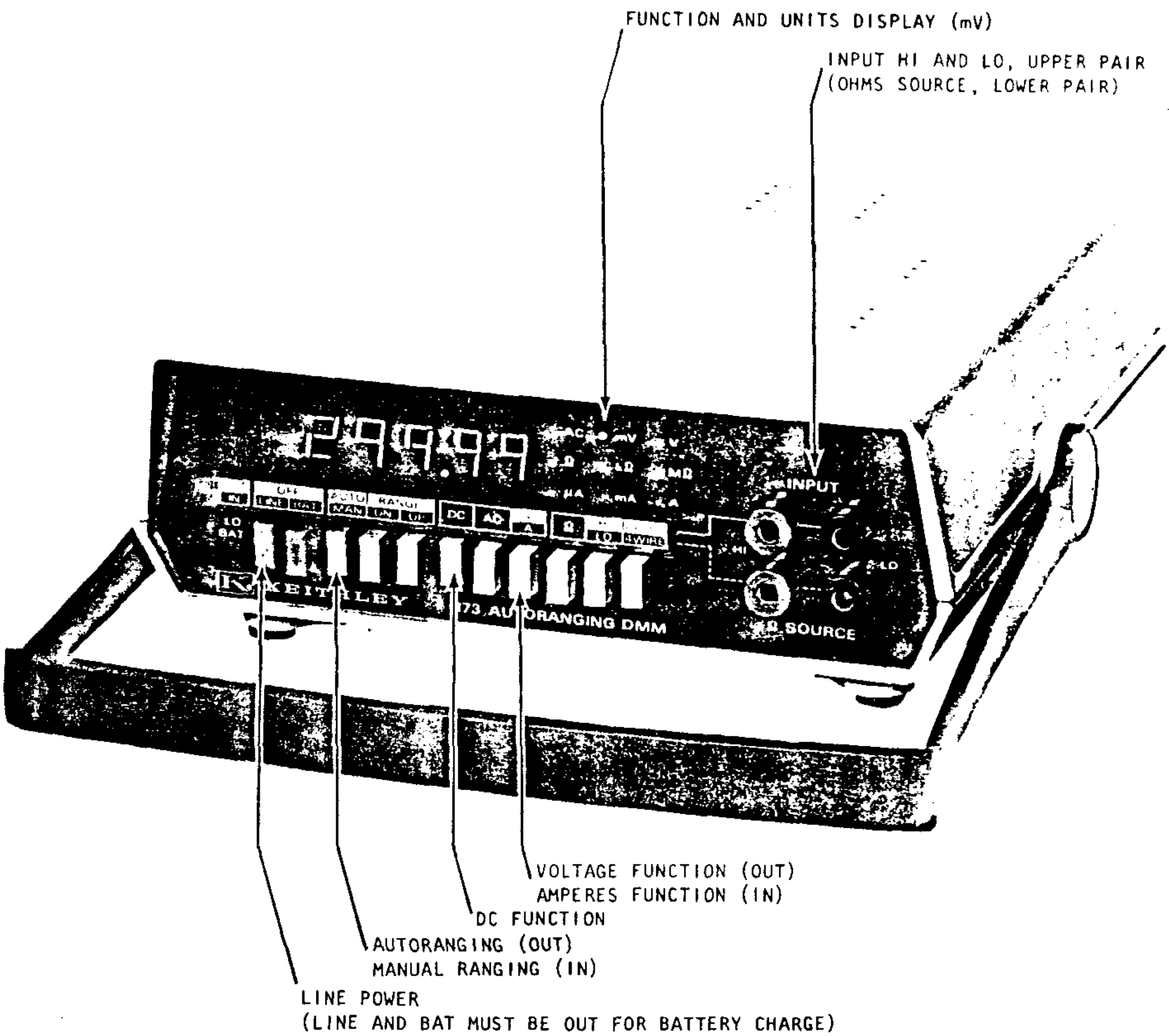


FIGURE 3. Model 173 Front Panel

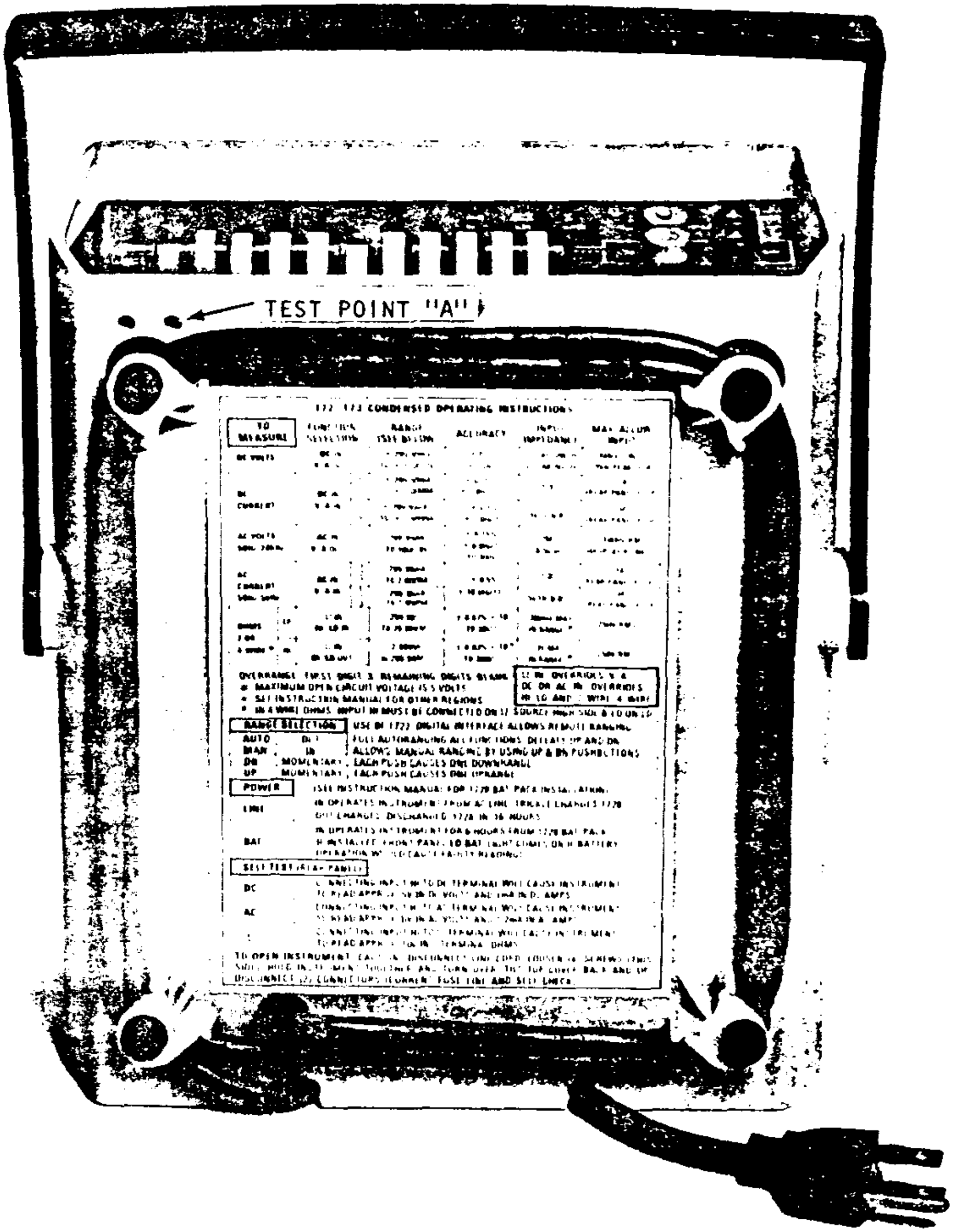


FIGURE 4. Bottom View Showing Line Cord

172, 173 CONDENSED OPERATING INSTRUCTIONS

TO MEASURE	FUNCTION SELECTION		RANGE (SEE BELOW)	ACCURACY	INPUT IMPEDANCE	MAX. ALLOW INPUT
DC VOLTS	DC-IN V/A-OUT		± 299.99mV TO ± 1200.0V	± 0.01% ± 1 DIGIT	$10^9\Omega$ BELOW 3V $10^7\Omega$ ABOVE 3V	600V CONT. ✲ 1200V PEAK, 3 SEC
DC CURRENT	DC-IN V/A-IN	172	± 299.99mA TO ± 2.0000A	± 0.25% ± 2 DIGITS	1.3Ω	2A (REAR PANEL FUSE)
		173	± 299.99µA TO ± 2.9999A	± 0.1% ± 2 DIGITS	1k TO 0.4Ω	3A (REAR PANEL FUSE)
AC VOLTS 50Hz-20kHz	AC-IN V/A-OUT		299.99mV TO 1000.0V	± 0.15% ✲ ± 6 DIGITS TO 300V	2MΩ & 50 pF	1000V RMS (DISPLAY BLINKS)
AC CURRENT 50Hz-5kHz	AC-IN V/A-IN	172	299.99mA TO 2.0000A	± 0.5% ± 18 DIGITS	1.3Ω	2A (REAR PANEL FUSE)
		173	299.99µA TO 2.9999A		1k TO 0.4Ω	3A (REAR PANEL FUSE)
OHMS 2 OR 4 WIRE ★ — LO	Ω-IN HI/LO-IN		299.99Ω TO 29.999 MΩ	± 0.03% ± 1D ✲ TO 30kΩ	300mV MAX. IN RANGE ⌗	250V RMS
OHMS 2 OR 4 WIRE ★ — HI	Ω-IN HI/LO-OUT		2.9999kΩ to 299.99MΩ	± 0.03% ± 1D ✲ TO 300kΩ	3V MAX. IN RANGE ⌗	250V RMS

OVERRANGE: FIRST DIGIT 3, REMAINING DIGITS BLANK
⌗ MAXIMUM OPEN CIRCUIT VOLTAGE IS 5 VOLTS.
✲ SEE INSTRUCTION MANUAL FOR OTHER REGIONS.
★ IN 4 WIRE OHMS, INPUT HI MUST BE CONNECTED ON Ω SOURCE HIGH SIDE & LO ON LO.

Ω IN: OVERRIDES V/A.
DC OR AC IN: OVERRIDES HI/LO AND 2 WIRE/4 WIRE.

RANGE SELECTION		USE OF 1722 DIGITAL INTERFACE ALLOWS REMOTE RANGING.
AUTO	OUT	FULL AUTORANGING ALL FUNCTIONS. DEFEATS UP AND DN.
MAN	IN	ALLOWS MANUAL RANGING BY USING UP & DN PUSHBUTTONS.
DN	MOMENTARY	EACH PUSH CAUSES ONE DOWNRANGE.
UP	MOMENTARY	EACH PUSH CAUSES ONE UPRANGE.

POWER	(SEE INSTRUCTION MANUAL FOR 1728 BAT. PACK INSTALLATION).
LINE	IN-OPERATES INSTRUMENT FROM AC LINE. TRICKLE CHARGES 1728. OUT-CHARGES DISCHARGED 1728 IN 16 HOURS.
BAT.	IN-OPERATES INSTRUMENT FOR 6 HOURS FROM 1728 BAT. PACK, IF INSTALLED. FRONT PANEL **LO BAT** LIGHT COMES ON IF BATTERY OPERATION WOULD CAUSE FAULTY READINGS

SELF TEST (REAR PANEL)	
DC	CONNECTING INPUT HI TO DC TERMINAL WILL CAUSE INSTRUMENT TO READ APPROX. 5V IN DC VOLTS AND 1mA IN DC AMPS.
AC	CONNECTING INPUT HI TO AC TERMINAL WILL CAUSE INSTRUMENT TO READ APPROX. 6V IN AC VOLTS AND 1.2mA IN AC AMPS.
Ω	CONNECTING INPUT HI TO Ω TERMINAL WILL CAUSE INSTRUMENT TO READ APPROX. 10k IN 2 TERMINAL OHMS.

TO OPEN INSTRUMENT: CAUTION—DISCONNECT LINE CORD. LOOSEN (4) SCREWS (THIS SIDE). HOLD INSTRUMENT TOGETHER AND TURN OVER. TILT TOP COVER BACK AND UP. DISCONNECT (2) CONNECTORS (CURRENT FUSE LINE AND SELF CHECK).

SECTION 2. INITIAL PREPARATION

2-1. GENERAL. This section provides information needed for incoming inspection and preparation for use.

2-2. INSPECTION. The Model 172/173 was carefully inspected both mechanically and electrically before shipment. Upon receiving the instrument, check for any obvious damages which may have occurred during transit. Report any damages to the shipping agent. To verify the electrical specifications, follow the procedures given in Section 6.

2-3. PREPARATION FOR USE. The Model 172/173 is shipped ready-to-use. The instrument can be powered from line voltage or from rechargeable nickel-cadmium batteries (when the optional Model 1728 Rechargeable Battery Pack is installed).

a. Line Power. The Model 172/173 has an attached three-wire line cord which mates with third-wire grounded receptacles (NEMA 5-15P). The permanently installed line cord is stored by wrapping the cord around the base of the instrument as shown in Figure 4.

CAUTION

⚠ This instrument has an internal line power selector switch that must be set to 234V position for operation above 125 volts rms, 50-60 Hz.

1. How to Set the Internal Line Voltage Switch (S601). The Model 172/173 has a two position slide switch located on the main circuit board. To set the switch for operation above 125 volts the switch setting must be changed. The top cover must be removed to gain access to the circuit board as described in MAINTENANCE section.

WARNING

Disconnect the line cord before removing the top cover of the instrument. Line voltage is present at various points on the circuit board and represents a SHOCK HAZARD.

NOTE

Other line voltage ranges are available when wiring modifications are made to transformer T601 as shown on schematic 28067D.

TABLE 2-1.
Summary of Standard and Optional Line Voltages

Standard	Optional	
105 to 125 V rms	90 - 105 V rms	Transformer wiring must be modified
210 to 250 V rms	195 - 210 V rms	

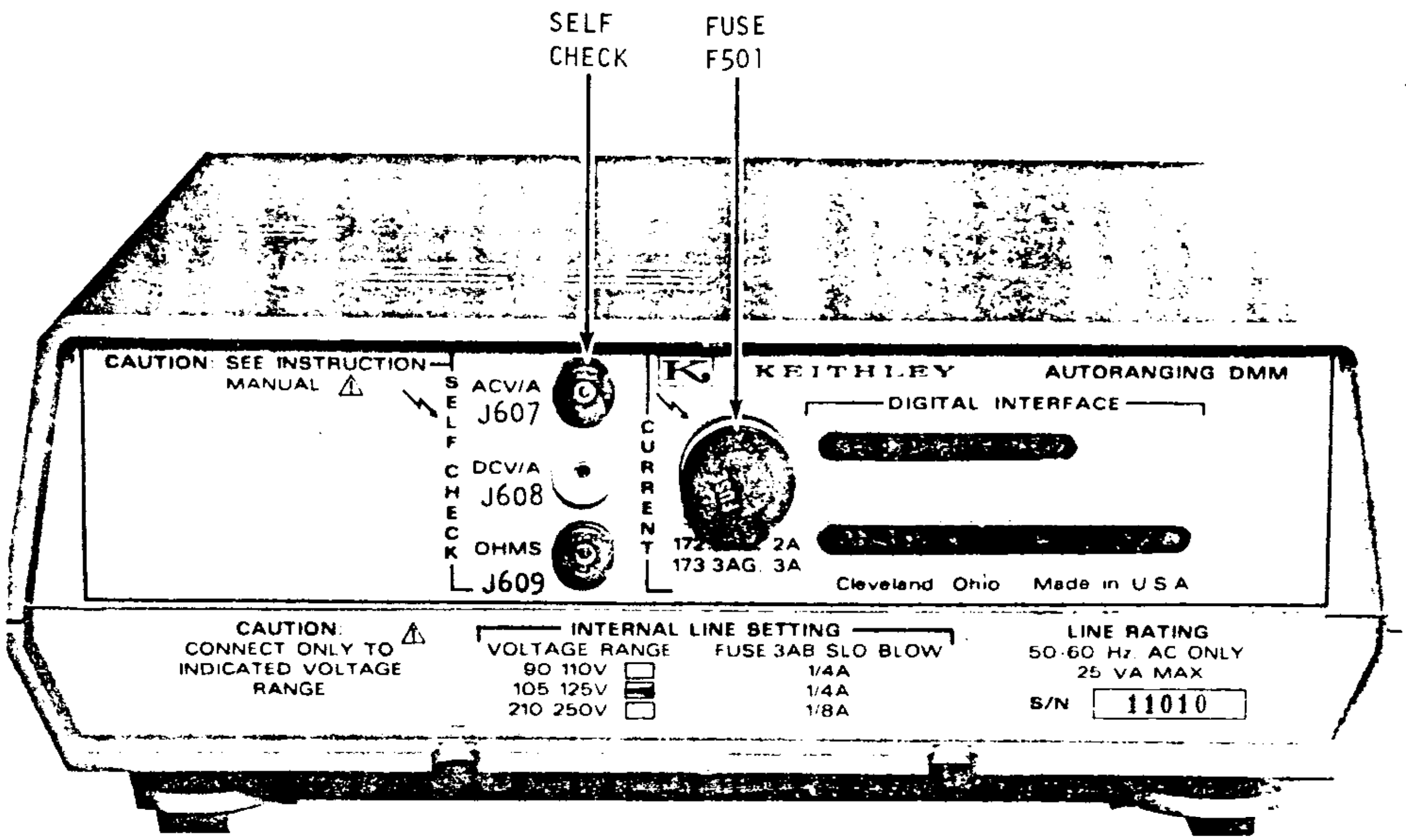


FIGURE 5. Rear Panel Showing Current Fuse and Check Points

2. Line Fuse Requirement. The Model 172/173 use a single line fuse to protect the line-operated power supply. The fuse is a 3 AB or 3 AG, slow-blow type. Replace with 1/4 ampere for 117 volts operation or 1/8 ampere for 234 volts.

IMPORTANT

⚠ Replace fuse with correct rating otherwise damage to the instrument could result.

3. How to Replace the Line Fuse. The fuse is installed on the main circuit board as shown in Figure 36 (page 6-10). The top cover must be removed to gain access to the circuit board as described in Section 6. Use Keithley FU-17 for 117 V; FU-20 for 234V.

WARNING

Disconnect the line cord before removing the top cover of the instrument. Line voltage is present at various points on the circuit board and represent a SHOCK HAZARD.

CAUTION

⚠ The fuse installed on the rear panel of the Model 172/173 is used only for current range protection. This fuse is not a line voltage protection fuse.

b. Battery Power. To operate the Model 172/173 from batteries, the Model 1728 Rechargeable Battery Pack must be installed. The Model 1728 can be either field or factory-installed (at the time the Model 172/173 is purchased).

NOTE

The Model 1728 Rechargeable Battery Pack can be installed by the user within the Model 172/173 at any time. However, if the Model 1722 Digital Output is already installed, the Model 1728 cannot be used simultaneously.

1. How to Install the Model 1728 Rechargeable Battery Pack. The batteries furnished with the Model 1728 are already installed in the battery pack. The battery pack includes 7 rechargeable "C" cells (1.2V, 2 AMP Hr) and two 19.2 volt packs (sixteen 1.2V-cells per pack). See Figure 6.

a) Check the fuses on the Battery Pack. Three fuses are used. All are 1 ampere, 3AB or 3 AG, Slo-Blo types, Keithley Part No. FU-10.

b) Check for proper installation of batteries in the Battery Pack. If replacement battery cells are to be installed, be certain to observe the proper polarity of the individual cells as shown in Figure 6.

c) To install the Battery Pack, turn the instrument over so that the bottom cover faces up. Loosen four slotted screws on the bottom cover as shown in Figure 4. The screws are captive, that is they cannot be removed completely. Turn over the instrument with the top cover facing up, taking care to hold the top and bottom covers together. Carefully remove the top cover to gain access to the printed circuit board. There are 2 connections between the top cover and the main circuit board which must be temporarily removed in order to free the top cover. Check to see that the four insulating spacers are in position on the circuit board as shown in Figure 7. Plug the two 5-wire connectors (J401, J402) into the mating receptacles (P602, P606) taking care to orient the connectors as shown. Place the Model 1728 in position on the spacers with the pack oriented as shown in Figure 7. Replace the connectors from the top cover to the circuit board. Replace the top cover. Turn over the instrument with the bottom cover facing up and tighten down the four slotted-head screws.

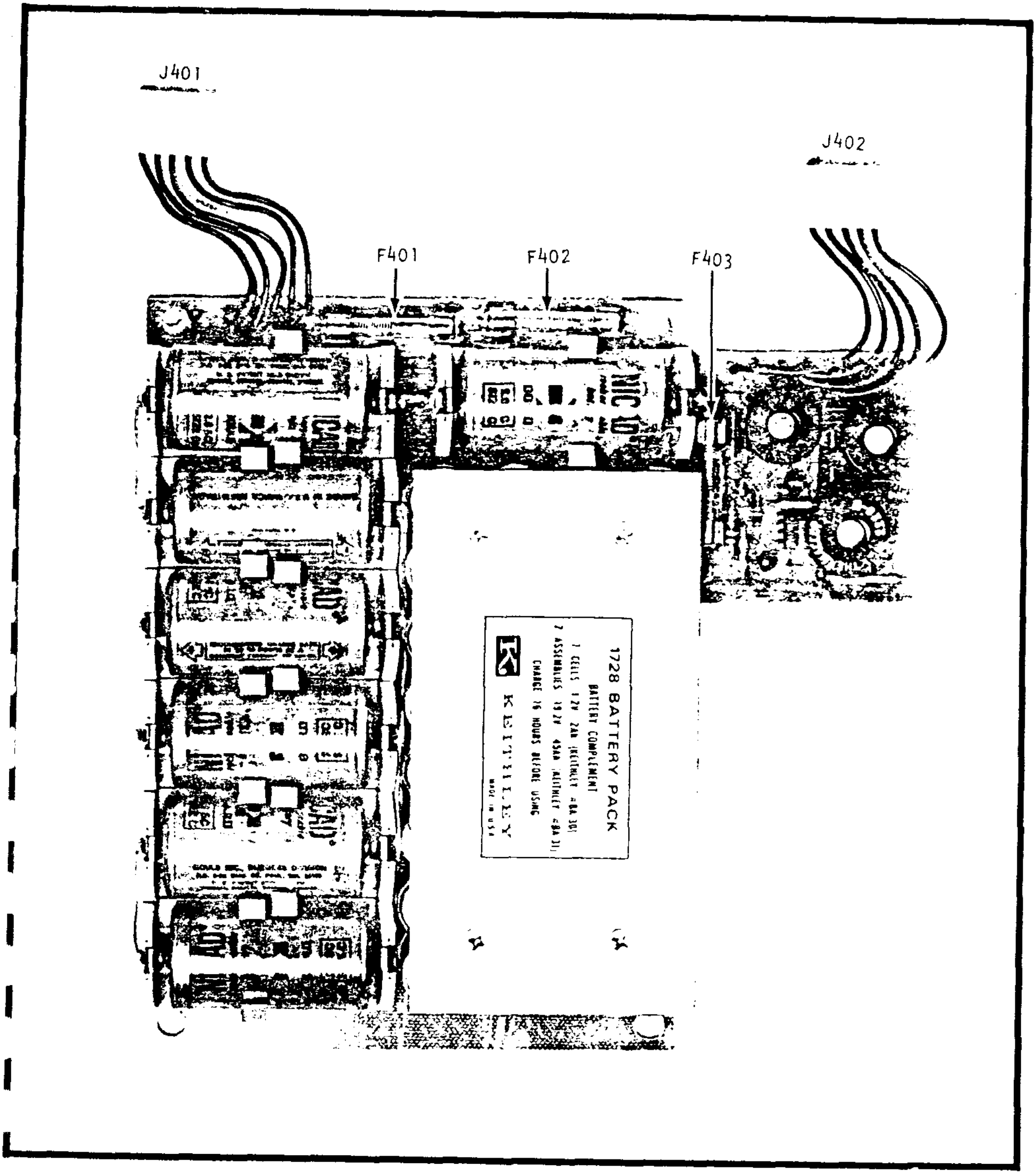


FIGURE 6. Model 1728 Rechargeable Battery Pack.

WARNING

Disconnect the line cord on the instrument before the Battery Pack is installed. Line voltage is present at various places on the circuit board and is a SHOCK HAZARD.

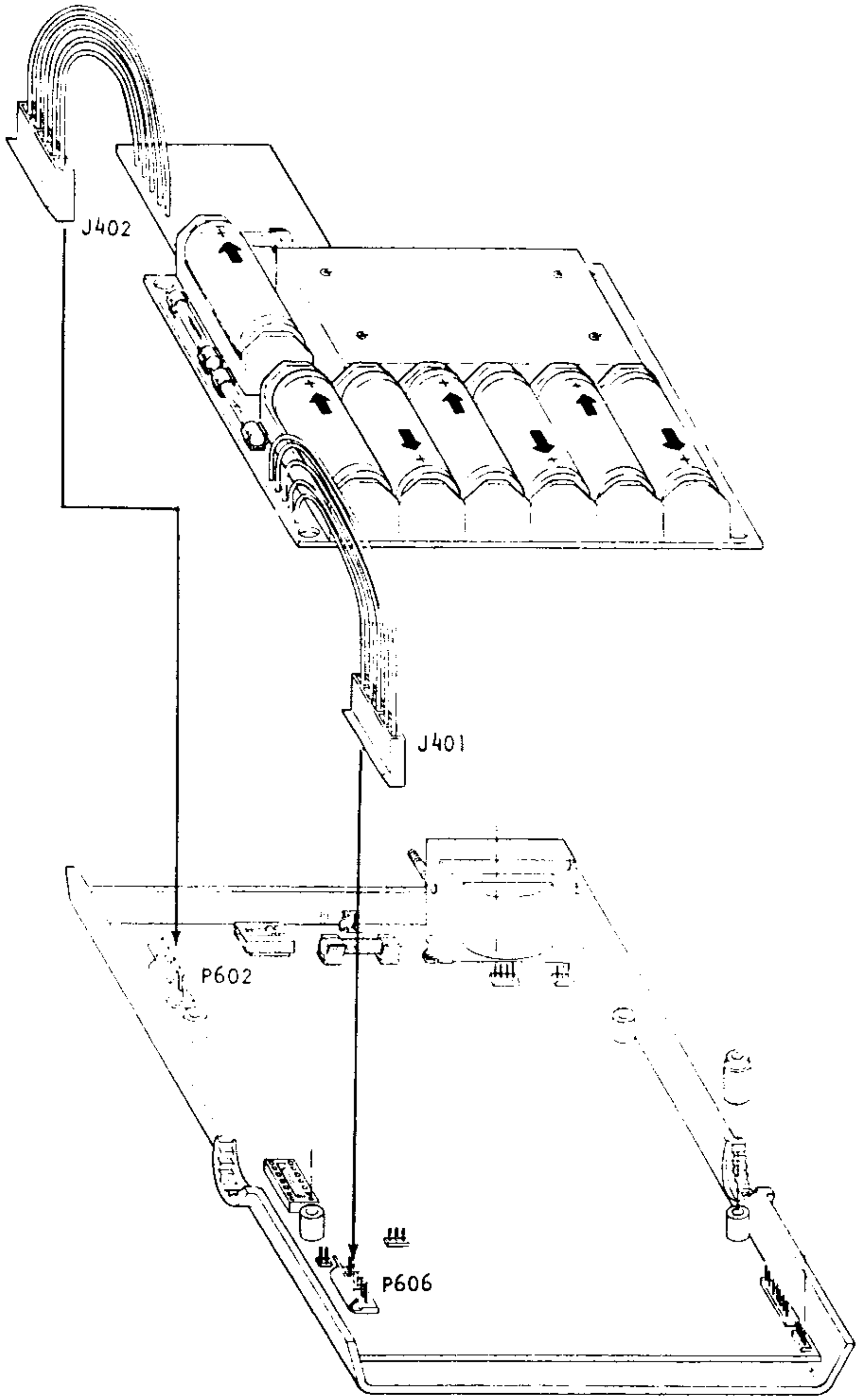


FIGURE 7. Installation of Battery Pack.

TABLE 2-2.
Summary of Batteries Used in the Model 1728

Description	Quantity	Voltage	Keithley Part No.
1.2V "C" cell (2 AMP-HR)	7	8.4V	BA-30
+19.2V pack (16-1.2V cells)	1	+19.2V	BA-31
-19.2V pack (16-1.2V cells)	1	-19.2V	BA-31

CAUTION

⚠ The Model 1728 is shipped from the factory in an uncharged condition. Therefore the pack should be installed in the Model 172/173 and charged prior to use.

2. How to Check Batteries.

a) The Model 172/173 has a built-in LO BAT indicator to permit easy determination of battery condition. The Model 172/173 also has an individual test point on the bottom panel usually needed only for troubleshooting purposes (See Figure 4.).

b) The LO BAT indicator will be lighted when the Battery Pack goes below normal operating voltage. When the indicator turns on the Model 172/173 should be switched to LINE or OFF to permit recharging of the Pack.

c) The test point may be checked at any time using the Model 172/173 or other measuring instrument. The voltages are summarized in Table 2-3.

IMPORTANT

The instrument must be operated in BAT mode in order to obtain a valid battery condition at test point "A". This will ensure that the batteries are supplying power to the instrument. If the voltage is measured when the Model 172/173 is operated in the LINE mode a different reading may be observed since the batteries are being charged.

TABLE 2-3.
Summary of Battery Voltage Levels (BAT mode)

Test Point	Acceptable Battery Levels		Recharge if Below	Battery Tested
	Range	Normal		
"A"	19V → +20.5V	+19.2	19V	BT402

3. How to Charge the Batteries. The Model 1728 provides built-in recharging circuitry. The Model 172/173 must be connected to line voltage. Recharging occurs at the most rapid rate when the Model 172/173 is set to OFF. Typically, the recharge time is 2.5 hours per hour of discharge.

CAUTION

⚠ Overcharging the batteries will raise the internal temperature of the battery pack and may shorten the life of the batteries.

SECTION 3. OPERATING INSTRUCTIONS

3-1. GENERAL. This section provides information needed to operate the Model 172/173 for measurement of voltage, current and resistance.

3-2. HOW TO SELECT POWER. The Model 172/173 may be powered from line voltage or rechargeable nickel-cadmium batteries (when the Model 1728 is installed). The Model 172/173 has a built-in line-voltage power supply and power cord.

NOTE

The accessory Model 1728 Rechargeable Battery Pack may be ordered at the time of purchase of the Model 172/173 or may be purchased and field-installed at a later time if so desired. The Model 1728 features plug-in wiring and, as a result, no modifications need to be made to the Model 172/173 chassis.

a. How to Operate from Line Power. The Model 172/173 can be powered from line voltage over four ranges from a minimum of 90 V rms to a maximum of 250 V rms. Table 3-1 summarizes the line voltages permitted.

1. Set the internal line voltage switch to either 117V or 234V.
2. Plug the line cord into source of line power.
3. Depress LINE pushbutton.

NOTE

Power on will be indicated by a lighted display with one or more digits and measurement unit showing.

TABLE 3-1.
How to Set Line Voltage

Range Desired	Switch S601	Transformer Modification*
90-105V	117V	Yes *
105-125V	117V	No
195-210V	234V	Yes *
210-250V	234V	No

*For these ranges the leads must be rewired

b. How to Operate from Battery Power.

1. Install the Model 1728 Rechargeable Battery Pack. (See Section 2, page 2-3.)
2. Depress BAT pushbutton.
3. If LO BAT indicator is lighted, the battery pack must be charged a minimum of 16 hours to provide fully charged operation of the Model 172/173.

NOTE

To charge the Model 1728, release both LINE and BAT pushbuttons and connect the line cord to line power. If it is desired to use the Model 172/173 immediately, depress LINE. The Model 172/173 will be useable for measurements although the battery charging rate is decreased considerably.

4. If the LO BAT indicator is not lighted in BAT mode, the model 172/173 may be used for measurements.

NOTE

The Model 1728 is shipped from the factory in uncharged condition. Therefore the Model 1728 should be installed and charged prior to use. After the Model 1728 has been charged for at least 16 hours, the Model 172/173 can be powered continuously for at least 6 hours.

TABLE 3-2.
Summary of Operation in LINE and BAT Modes

	Condition of Instrument		
Button Depressed	Line Power Connected 1728 not installed	Line Power Connected 1728 installed	Line Power Not Connected 1728 installed
LINE	ON	ON Battery trickle charged.	OFF
BAT	OFF	ON Battery slowly discharged.	ON
NEITHER LINE NOR BAT	OFF	OFF Battery charged at maximum rate.	OFF

3-3. HOW TO SELECT FUNCTION. Function is selected by means of four pushbuttons AC, DC, V/A, and Ω

a. DC. This pushbutton must be used with V/A to select either DC voltage or DC current functions.

1. DC Voltage. Depress DC Release V/A
2. DC Current. Depress DC Depress V/A

b. AC. This pushbutton must be used with V/A to select either AC voltage or AC current functions.

1. AC Voltage. Depress AC Release V/A
2. AC Current. Depress AC Depress V/A

c. V/A. This pushbutton selects either voltage V or current A. When V/A is depressed, along with DC or AC, a shunt resistor is connected across the HI and LO terminals to provide current sensing.

d. Ω. Depress Ω to measure resistance.

NOTE

DC, AC, and Ω pushbuttons are interlocked so that only one pushbutton is depressed at a time. However, it is possible to have all pushbuttons out which disconnects the input HI and LO terminals and no measurement can be made. (The Ω indicator will be lighted in this instance.)

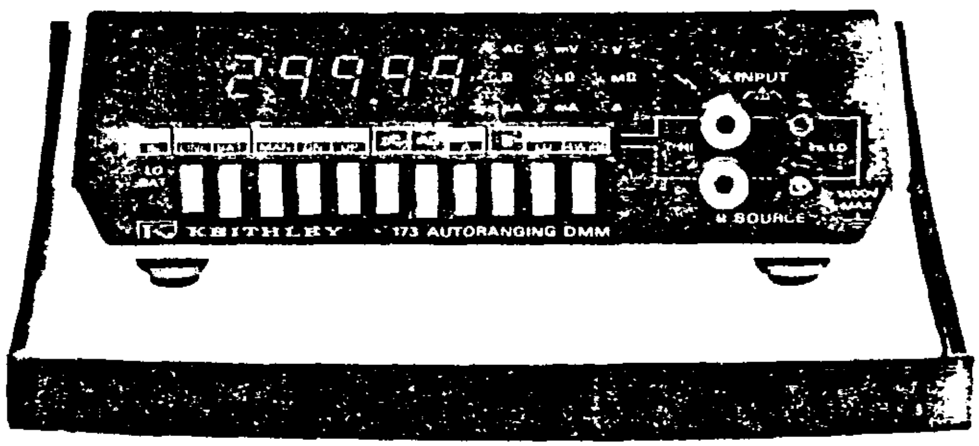


FIGURE 8. Front Panel Pushbutton Selection.

3-4. HOW TO SELECT RANGE. The Model 172/173 provides automatic or manual ranging. The AUTO/MAN pushbutton determines the ranging mode, where AUTO = fully automatic ranging.

a. AUTO. When released, the Model 172/173 automatically selects the appropriate range in accord with the following rules.

1. When the display exceeds 29999 the Model 172/173 upranges (that is, it changes to less sensitivity and the decimal point moves appropriately).

2. When the display reaches 02599 the Model 172/173 downranges (that is it changes to greater sensitivity and the decimal point moves appropriately).

b. MAN. When depressed the range is placed in hold. The user can cause the Model 172/173 to uprange or downrange by using the UP RANGE and DN RANGE pushbuttons.

1. When DN RANGE is momentarily depressed the Model 172/173 will downrange one decade of sensitivity. Each time the pushbutton is depressed and released, one downrange will occur until most sensitive range is obtained.

2. When UP RANGE is momentarily depressed the Model 172/173 will uprange one decade of sensitivity. Each time the pushbutton is depressed and released, one uprange will occur until least sensitive range is obtained.

3-5. HOW TO MEASURE VOLTAGE. The Model 172/173 measures ac and dc voltage in five ranges: 0.3V, 3V, 30V, 300V and 1200V DC (1000VAC).

CAUTION

⚠ Maximum input voltage depends on the range selected. Table 3-3 gives the maximum allowable continous input for each range on AC and DC. Do not exceed these voltages or damage to the instrument will occur.

TABLE 3-3.
Maximum Allowable Continuous Input

Range	AC Voltage (ACV)	DC Voltage (DCV)
0.3V	1000V rms	1200V peak*
3 V	1000V rms	1200V peak*
30 V	1000V rms	1200V peak
300 V	1000V rms	1200V peak
1000 V	1000V rms	1200V peak

a. DC Voltage. The Model 172/173 detects dc voltages from ±10 microvolts/digit to ±1200 volts (1200.0 display). The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked. The display blinks above 1199.9 volts on the highest range.

1. Set to DC Volts.

2. Set to AUTO.

3. Connect the Signal to be measured between HI and LO terminals. (The terminals are designed to accept banana style plugs. Such as Keithley part no. BG-5 or accessory test leads such as Model 1681 Clip-On Test Leads.)

4. Observe the displayed digits, polarity sign, decimal point location, and measurement unit (mV or V). If no polarity sign is indicated, a positive polarity is implied.

b. AC Voltage. The Model 172/173 detects ac voltages from 10 microvolts rms to 1000 volts (1000.0 display). The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked. The display blinks above 999.9 volts on the highest range.

1. Set to AC Volts. (The AC indicator should be lighted.)

2. Set to AUTO.

3. Connect the signals to be measured between HI and LO terminals. (The terminals are designed to accept banana style plugs, such as Keithley part no. BG-5 or accessory test leads such as Model 1681 Clip-On Test Leads.)

4. Observe the displayed digits, decimal point location, and measurement unit (mV or V).

3-6. HOW TO MEASURE CURRENT. (MODEL 172 ONLY). The Model 172 measures ac and dc current in two ranges: 0.3A, and 2A. The current is limited by the current fuse even though the DMM is capable of displaying 2.9999A.

CAUTION

⚠ The Model 172 is protected by a 2 ampere fuse on all ranges. If the fuse is blown, a replacement Keithley Part No. FU-13 should be installed in the rear panel fuse holder. (See Figure 5.)

a. DC Current. The Model 172 detects dc currents from ±10 microamperes/digit to ±2 amperes. When the input exceeds 2 amperes, the current fuse will blow. When using the MAN mode it is possible to select 30A, 300A & 3000A Ranges, but 2A Max is still the limit.

1. Set to DC Amperes.

2. Set to AUTO.

3. Connect the signal to be measured at the HI terminal.

4. Observe the displayed digits, polarity sign, decimal point location, and measurement unit (μA, mA, or A). If no polarity sign is indicated, a positive polarity is implied.

b. AC Current. The Model 173 DMM detects ac currents from 10 nanoamperes rms/digit to 3 amperes rms. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked.

1. Set to AC Amperes. (The AC indicator should be lighted.)

2. Set to Auto.

3. Connect the signal to be measured at the HI terminal.

4. Observe the displayed digits, decimal point location, and measurement unit (AC μA, AC ma, or AC A).

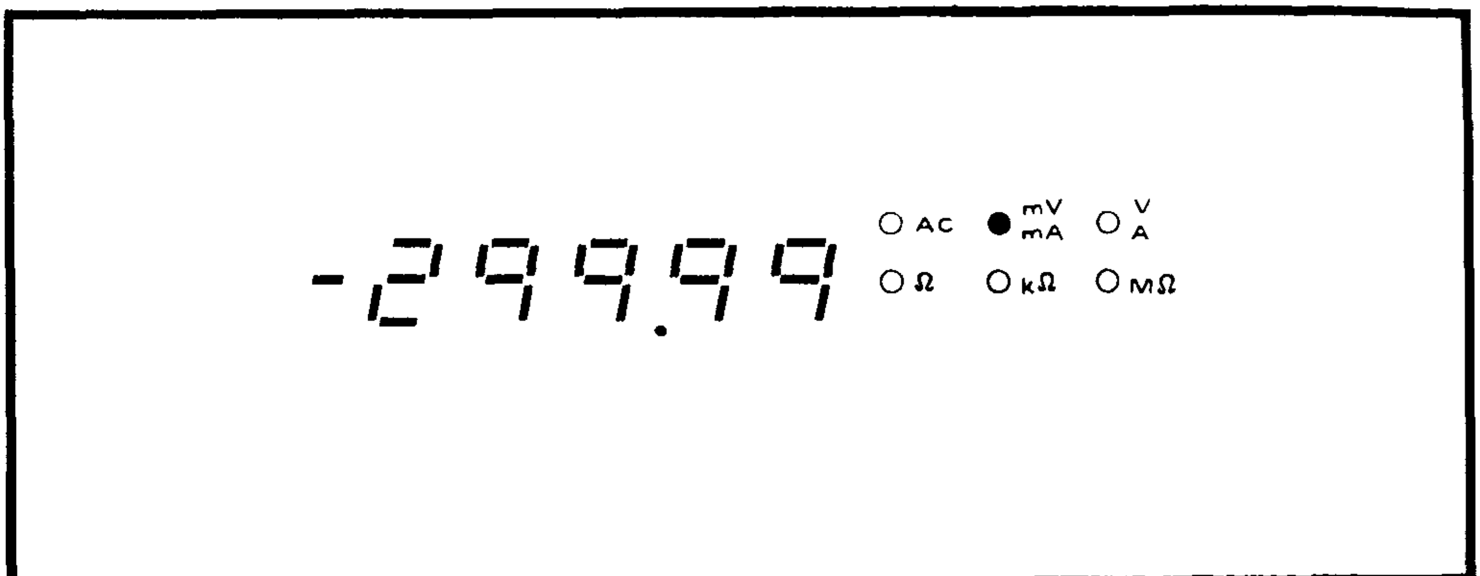


FIGURE 9. Typical Model 172 Current Display (DCmA).

3-7. HOW TO MEASURE CURRENT. (MODEL 173 ONLY.) The Model 173 measures ac and dc current in five ranges: 0.3mA, 3mA, 30mA, 0.3A, and 3A.

CAUTION

⚠ The Model 173 DMM is protected by a 3 ampere fuse on all ranges. If the fuse is blown, a replacement Keithley Part No. FU-2 should be installed in the rear panel fuse holder. (See Figure 5.)

a. DC Current. The Model 173 DMM detects dc currents from ±10 nanoamperes to ±3 amperes. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked.

1. Set to DC Amperes.
2. Set to AUTO.
3. Connect the signal to be measured at the HI terminal.
4. Observe the displayed digits, polarity sign, decimal point location, and measurement unit (A, mA, or A). If no polarity sign is indicated, a positive polarity is implied.

b. AC Current. The Model 173 DMM detects ac currents from 10 nanoamperes rms/digit to 3 amperes rms. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked.

1. Set to AC Amperes. (The AC indicator should be lighted.)
2. Set to AUTO.
3. Connect the signal to be measured at the HI terminal.
4. Observe the displayed digits, decimal point location, and measurement unit (AC, A, AC ma, or AC A).

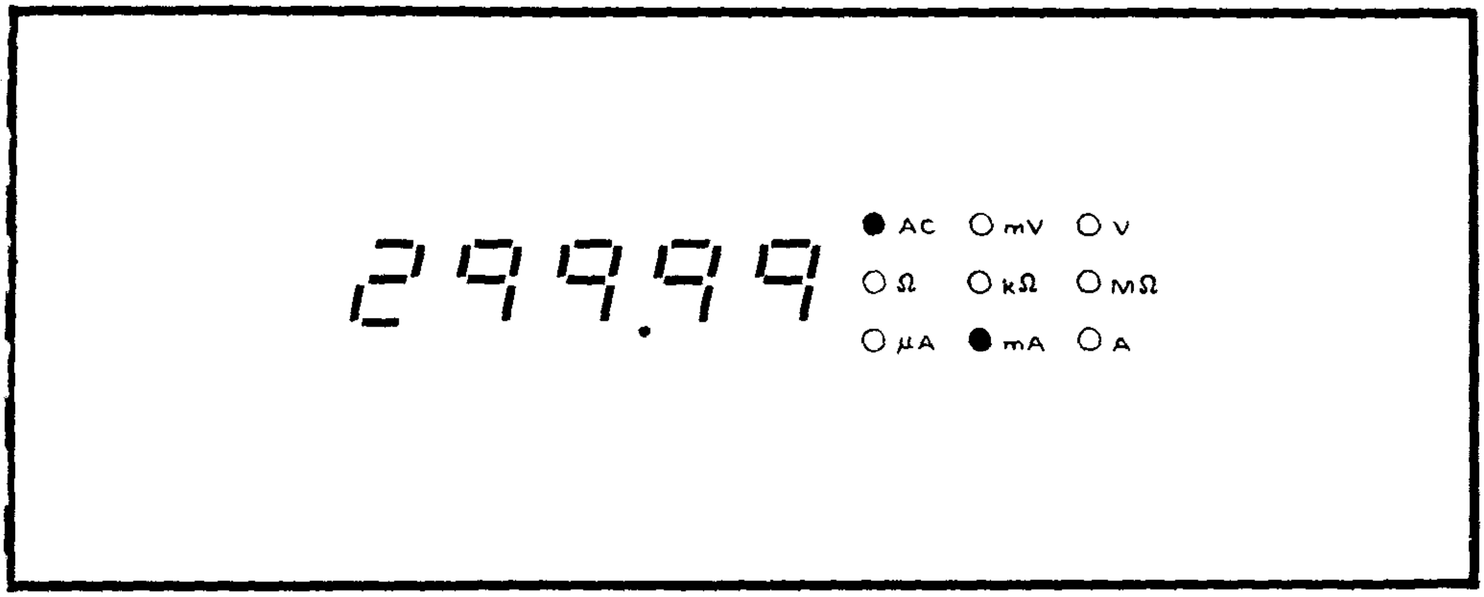


FIGURE 10. Typical Model 173 Current Display (ACmA).

3-8. HOW TO MEASURE RESISTANCE. The Model 172/173 measures resistance from 10 milliohms/digit to 300 megohms. The maximum display is 29999. When the display exceeds 29999, a 3 remains lighted, but all other digits are blanked.

a. HI Ohms Measurement. When the HI/LO pushbutton is released (set to HI), the voltage developed across the resistance under test at full range is 3 volts. The Model 172/173 measures to 300 megohms in HI mode. For the 2 wire method the lower set of terminals is not used.

1. Set to HI Ohms.
2. Set to 2 WIRE.

NOTE

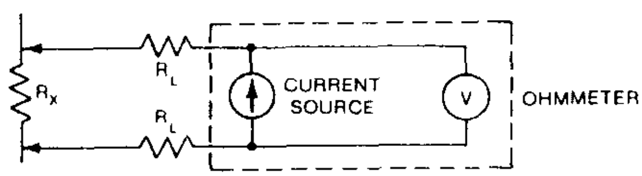
When the Model 172/173 is set to 2 WIRE, the lower set of HI and LO input terminals are not connected. When set to 4 WIRE, the higher set of HI and LO input terminals are used as "voltage sensing" terminals. See Section 3-9 for more detailed information.

3. Set to AUTO.
4. Connect the resistance under test between the upper set of HI and LO terminals.
5. Observe the displayed digits, decimal point location, and measurement unit (Ω, KΩ, or MΩ).

b. LO Ohms Measurement. When the HI/LO pushbutton is released (set to LO), the voltage developed across the resistance under test at full range is 300 millivolts. The Model 172/173 measures to 30 megohms in LO mode. For the 2 wire method the lower set of terminals is not used.

1. Set to LO Ohms.
2. Set to 2 WIRE.
3. Set to AUTO.
4. Connect the resistance under test between the upper set of HI and LO terminals.
5. Observe the displayed digits, decimal point location, and measurement unit (Ω, KΩ, or MΩ).

This illustration is typical of a 2-terminal ohmmeter design.



When measuring resistance less than 1000 ohms it may be necessary to use the 4-wire mode to eliminate the measuring error of the test leads. For example a pair of 10ft leads made from 18 AWG copper wire has 0.14 ohms resistance.

FIGURE 11. Typical 2 WIRE Resistance Measurement.

3-9. FURTHER MEASUREMENT CONSIDERATIONS.

a. DC Voltage Measurements.

1. Overloads. When the display exceeds ±1200.0V DC all digits blink to indicate an overload condition.

2. Input Resistance. The input resistance is 1,000 MΩ on the 0.3V and 3V ranges; 10 MΩ on the 30V, 300V, and 3000V ranges. The effects of circuit loading should be considered when evaluating total accuracy of measurement. (See Accuracy.)

3. Accuracy. The Model 172/173 accuracy is specified in terms of % of reading and a % of range. For a full range reading of 299.99 mV DC the accuracy of measurement would be ± (0.03 mV + 0.01 mV) or ±0.04 mV. Measurements from relatively high source resistances could cause an additional reading error. The amount of error due to loading can be determined by the following relationship:

$$\%\ error = 100 \times Rs \div (Rs + Rl)$$

where Rs = source resistance in ohms
Rl = input resistance of Model 172/173 in ohms

4. Self-Check Feature. The Model 172/173 has a rear panel Voltage test point for functional check of the Model 172/173 in DC Volts. To use this feature, connect the input HI terminal to the rear panel white terminal. Verify a display of approximately 5 volts dc. To check dc current, depress V/A and verify a display of 1 mA.

b. AC Voltage Measurements

1. Overloads. When the display exceeds 1000.0 V AC (rms) all digits blink to indicate an overload condition.

2. Input Impedance. The input impedance is 2 megohms shunted by less than 50 picofarads. The effects of circuit loading should be considered when evaluating the total accuracy of measurement. (See Accuracy.)

3. AC-to-DC Conversion. The Model 172/173 operates as an average-reading voltmeter, calibrated in terms of the root-mean-square (rms) of a sine wave. The calibration is exact for sinusoidal waveforms in the specified frequency range.

4. Frequency Response. The frequency range given in the specifications is the minimum and maximum frequencies which accuracy is valid.

5. Accuracy. The Model 172/173 accuracy is specified in terms of a % of reading and a % of range. Measurements from relatively high source impedance could cause an additional reading error. The amount of error due to loading can be determined by the following relationship:

$$\%\ error = 100 \times \frac{Zs}{Zs + Zin}$$

where Zs = source impedance
Zin = effective input impedance of Model 172/173

6. Self-Check Feature. The Model 172/172 has a rear panel Voltage test point for functional check of the Model 172/173 in AC Volts. To use this feature, connect the HI terminal to the rear panel red terminal. Connect the line cord to line voltage. Verify a display of approximately 6 volts ac. To check ac current, depress V/A and verify a display of approximately 1.2 mA.

c. Current Measurements.

1. Overloads. Fuses are as follows: Model 172: 2A Model 173: 3A

2. Shunt Resistance. The Model 173 develops approximately 300 millivolts across the input terminals at full range. The 172 has 1.3 Ω on all ranges.

For example, on the 300 milli-ampere range the shunt resistor is 1.3 ohm, which results in a voltage drop of 0.3 x 1.3 = 390 millivolts at full range.

3. Accuracy. The Model 172/173 accuracy is specified in terms of a % of reading and a % of range. An additional reading error should be considered if the source resistance is not greater than 1000 times the shunt resistor. The amount of error can be determined by the following relationship:

$$\% \text{ error} = \frac{100 \times Rin}{Rs + Rin}$$

where Rin = shunt resistance of the Model 172/173
Rs = source resistance.

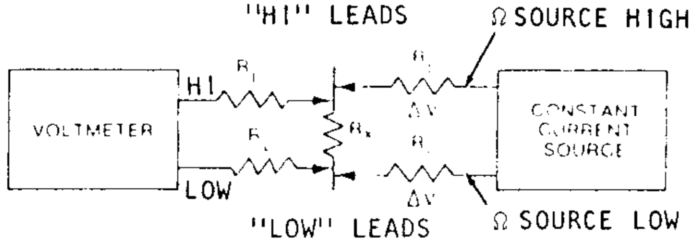
d. Resistance Measurements.

1. Maximum Allowable Voltage Input. The maximum input should not exceed 250V rms sine wave or ±250V dc.

2. Polarity of Ohms. The Model 172/173 provides a positive voltage at the HI terminal.

3. Maximum Open-Circuit Voltage. When the HI and LO terminals are open in either HI or LO ohms, the maximum voltage developed between HI and LO is +5 volts.

This illustration is typical of a 4-terminal measuring technique using a separate Voltmeter and Current Source. The Model 172/173 combines these features.



When using the 4-WIRE method, connect one pair of "current" leads to Ω SOURCE input. Connect a second pair of "voltage" leads to HI and LO. Then set to 4 WIRE.

Care should be taken to connect "current" leads and "voltage" leads properly. The LO terminal and Ω Source low must always connect to the same side of the unknown resistance.

FIGURE 12. Typical 4 WIRE Resistance Measurement.

4. Four-terminal Measurements. The 4-WIRE mode connects the lower set of Ω SOURCE terminals to the DMM ohmmeter source. As shown in Figure 12 the lower terminals are the current carrying terminals while the upper terminals are the voltage sensing terminals. This arrangement eliminates the error due to voltage drop across the current-carrying leads.

5. Semiconductor Diode and Transistor Testing. The Model 172/173 can be used to test diodes and transistors to determine the relative condition of the device. For semiconductor diodes, the voltage applied must be sufficient to cause conduction in the forward direction. The "HI OHMS" mode provides a voltage up to 3 volts at a current upto 1 milliampere. Since the HI terminal is positive with respect to LO terminal, connections should be made as shown in Figure 13 to cause forward conduction of diodes. Since the maximum current is available on the 3 KΩ range, depress AUTO/MAN (Set to MAN) and manually range to the 3 KΩ range (down-range).

6. Self-Check Feature. The Model 172/173 has a rear panel ohms test point for functional check of the Model 172/173 in OHMS. To use this feature, place the DMM in OHMS and 2 WIRE mode. Connect the HI terminal to the blue terminal. Verify a display of approximately 10 kilohms.

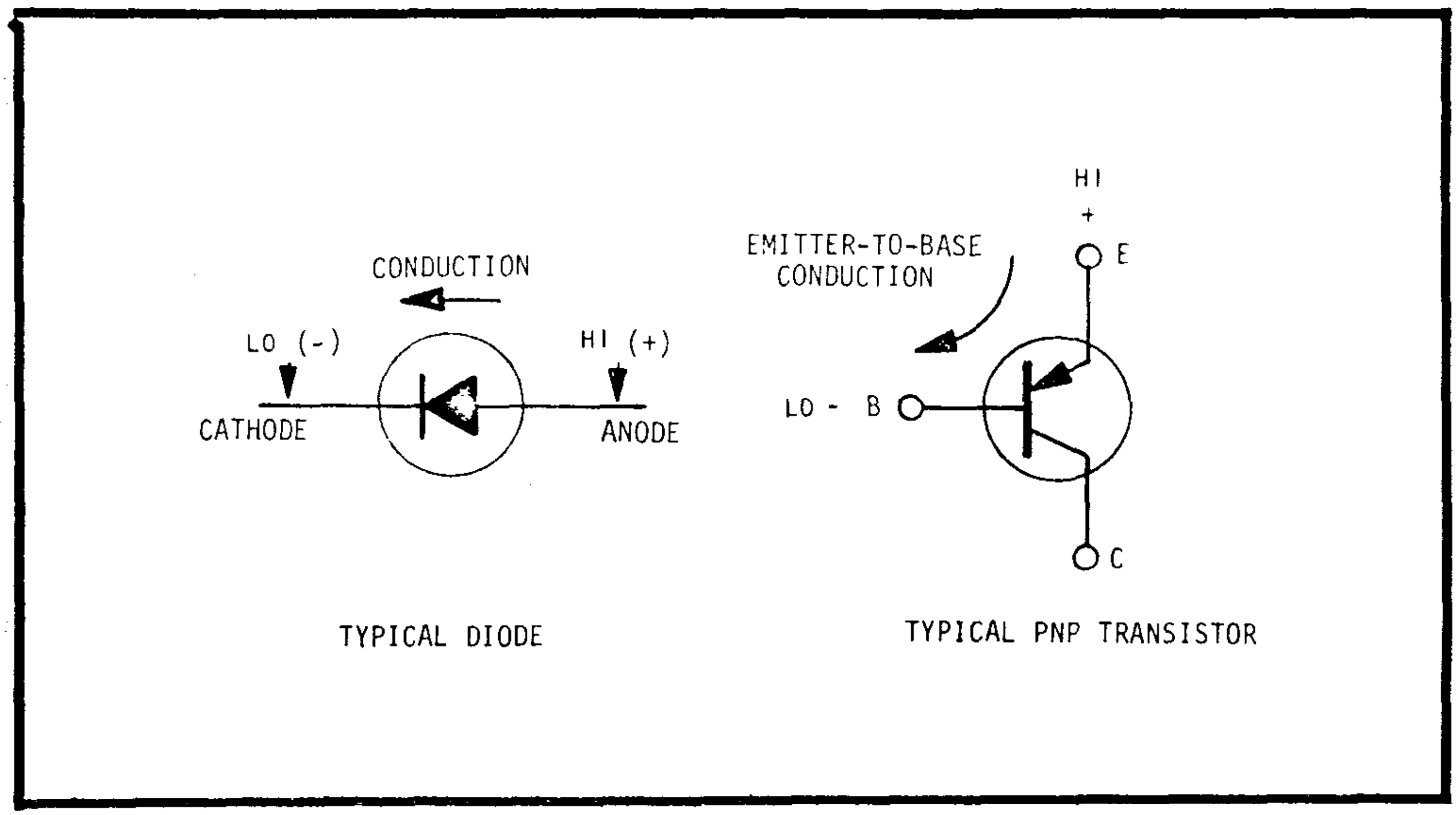


FIGURE 13. Semiconductor Diode and Transistor Testing.

3-10. HOW TO USE MODEL 172/173 OFF-GROUND. The "LO" terminal can be operated off ground at potentials of up to ±1400V. Isolation from the "LO" terminal to power line ground is specified at 1000MΩ, or $10^9\Omega$ (shunted by 300pF). Typically, the isolation resistance from LO to GND is two decades greater than $10^9\Omega$ ($10^{11}\ \Omega$). Because of this excellent isolation, operating the Model 172/173 off ground results in very little loading (from LO to GND) of a floating source. At 1000V above ground, the Model 172/173 will require, typically, only 10nA from the source. The excellent isolation also accounts for the high common-mode rejection ratio of the Model 172/173. Even with the "HI" terminal driven and a source resistance of 1kΩ, 1000 VDC (from HI to GND) will produce typically only 10μV DC error. This error voltage is determined directly from the ratio of the source resistance to the "isolation" resistance (See Figure 14).

$$I = \frac{1000V}{10^{11}\Omega} = 10^{-8}A \qquad V_{across\ 1k} = I \times 1k\Omega = 10^{-8} \times 10^3 = 10\mu VDC$$

The "isolation" capacitance from LO to GND is important when AC common-mode signals are present. In the Model 172/173 this capacitance is specified at 300 pF. At a frequency of 60Hz, 300 picofarads has a reactance of approximately 10MΩ. With the HI terminal driven and a source impedance of 1kΩ, a 1000V p-p, 60 Hz, common-mode signal will produce a voltage of only 100mV p-p across the input terminals. This 100mV p-p signal will be further rejected by the input filter and A-D converter so that the total rejection at the digital display is at least 120 dB (HI driven, 1kΩ source impedance). For DC voltage measurements, rejection is much greater than specified when the Model 172/173 LO terminal is driven, rather than the HI terminal. Where there is a need for even greater isolation from LO to power line ground, or where there is a need to float at potentials greater than 1400 volts above power line ground the Model 1728 Battery Pack should be used.

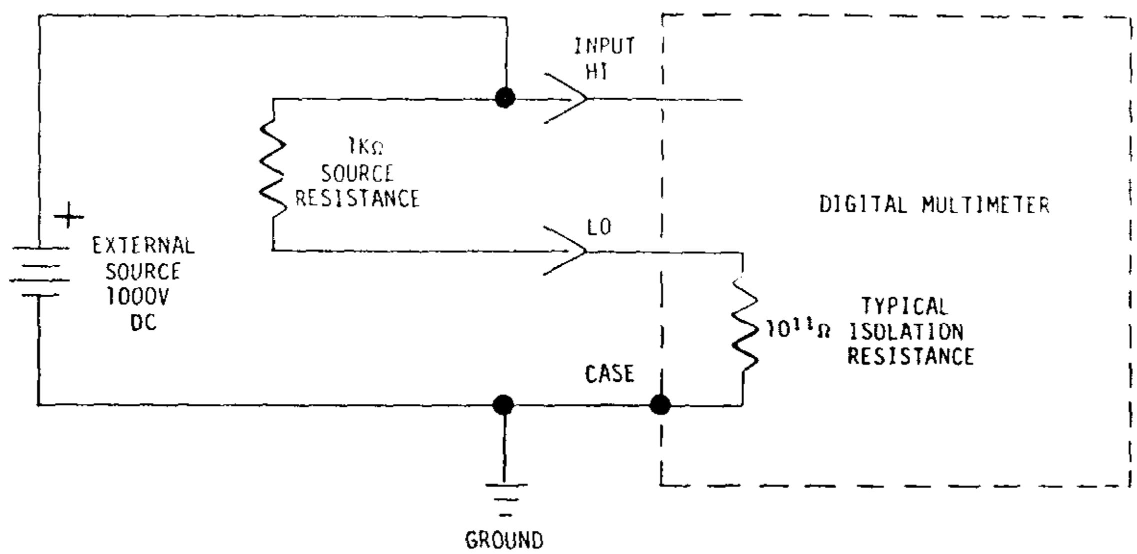


FIGURE 14. Use of Multimeter Off Ground.

3-11. HOW TO USE OPTIONAL PROBES AND SHUNTS.

a. Model 1600 High Voltage Probe. Set the Model 172/173 to DC volts and 30 volt range. The input resistance on the 30 volt range is 10 megohms so that no shunt resistor is needed. The Model 1682 has a 1000:1 division ratio. For maximum safety review the instructions furnished with the Model 1600 probe above 30kV, switch to the 300V range.

CAUTION

⚠ The alligator clip (ground) must be connected to the source low so that high voltage is not applied between low and ground. Severe damage to the instrument will occur if the alligator clip is not connected.

b. Model 1682 RF Probe. Set the Model 172/173 to DC volts and 30 volt range. The Model 1682 has a 1Vdc output corresponding to 1 V rms input over the range 100 kHz to 100 MHz.

IMPORTANT

For use on the 3 volt range the banana plug adapter (with 10 megohm resistor) should be used since the Model 172/173 input resistance is >1000 megohms on the 3 volt and 0.3 volt ranges.

c. Model 1685 Clamp-On AC Current Probe. Set the Model 172/173 to AC volts and 0.3 volt range. The Model 1685 provides a 0.1 volt rms output corresponding to a 1 ampere rms input. Review the instructions furnished with the Model 1685 to achieve best possible accuracy.

d. Model 1651 Current Shunt. Set the Model 172/173 to AC or DC volts (as appropriate) and 0.3 volt range. Connect the voltage leads to the Model 172/173 input terminals. Connect separate leads (not furnished) between the source and the Model 1651 hex-head bolts. The Model 1651 shunt resistance is 0.001 ohm which produces a sensitivity of 1 millivolt per ampere.

3-12. HOW TO USE THE MODEL 1722 DIGITAL INTERFACE.

a. General. THE Model 1722 provides binary coded decimal outputs (8421) and range control lines. Outputs are open-collector positive true unless otherwise specified. This accessory is available either "factory installed" or "field-installable". The Model 1722 consists of a two-layer circuit with card-edge and mating output connectors.

b. Installation.

1. Disconnect the Model 172/173 line cord from line voltage.

2. Turn the instrument over so that the bottom cover faces up.

3. Loosen four slotted screws on the bottom cover as shown in Figure 4. The screws are captive, that is, they cannot be removed completely.

4. Turn over the instrument with the top cover facing up, taking care to hold the top and bottom covers together.

5. Carefully remove the top cover to gain access to the printed circuit board. There are 2 connections between the top cover and the main circuit board which must be temporarily removed in order to free the top cover (see Figure 40.)

6. Remove the Model 1728 Rechargeable Battery Pack.(if installed). Carefully disconnect connectors from the mother board.

NOTE

The Models 1722 and 1728 cannot be installed on the Model 172/173 chassis at the same time.

7. Check to see that the four insulating spacers are in position on the circuit board as shown in Figure 16.

8. Place the Model 1722 on the spacers as shown in Figure 16.

9. Lift up the Model 1722 slightly to gain access to the Model 172/173 mother board, and plug in connectors J1003, J1002, and J1001 (in order given).

10. Connect ground return wire from the Model 1722 to the extra lug on transformer T101.

11. Replace the connections to the top cover.

12. Reinstall the top cover.

13. Turn the instrument over and tighten the four screws.

c. Connector Terminations. The Model 1722 uses two card-edge connectors P1006 (40-pin) and P1101 (26-pin). Ribbon cable style of mating connectors may be used with these cardedge connectors as shown in Table 3-5.

TABLE 3-5.
Summary of Mating Connectors

	Manufacturer	Crimped Ribbon-Cable Style
P1101	3M	3462-0000
P1006	3M	3464-0000

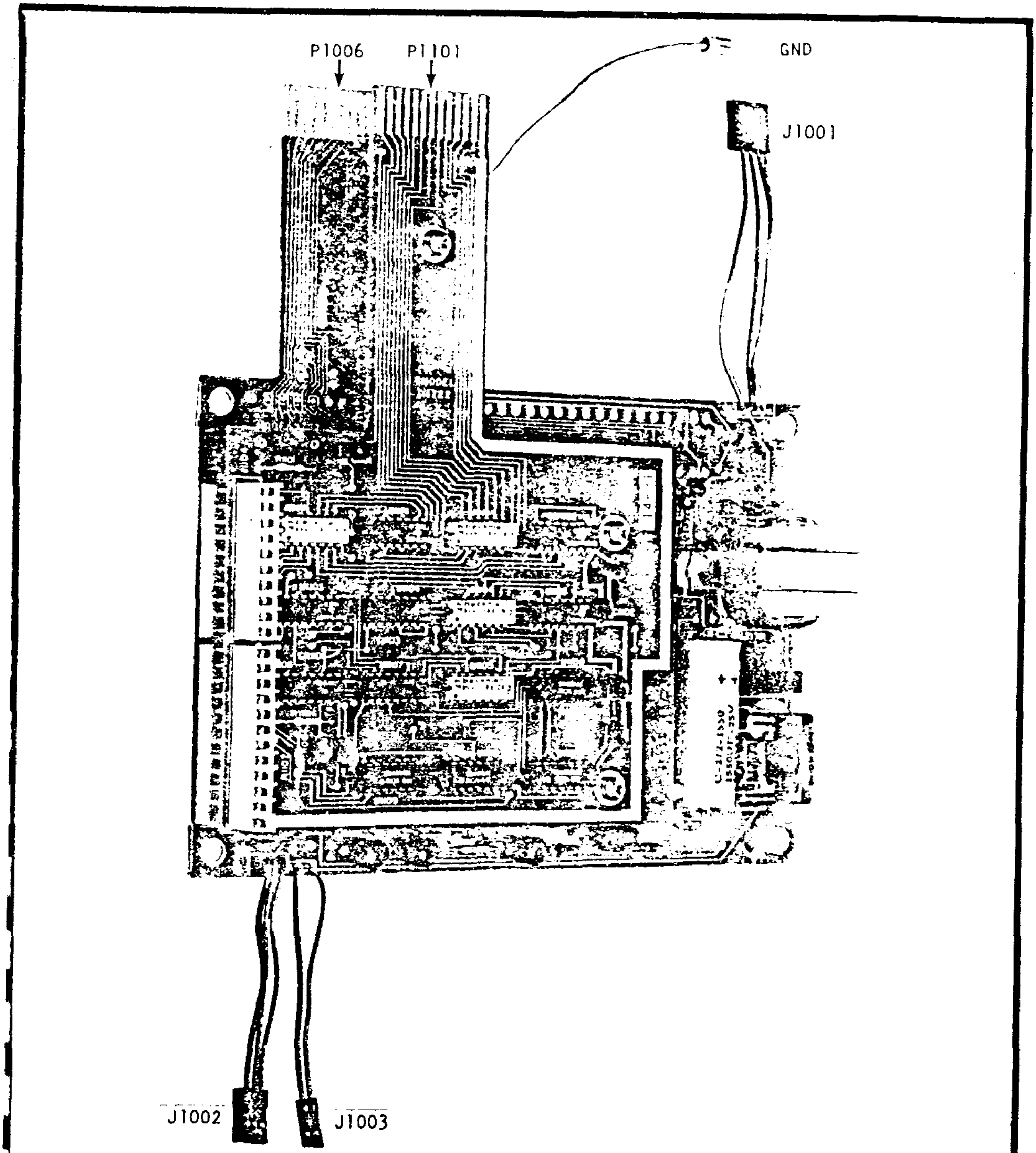


FIGURE 15. Model 1722 Digital Output Interface.

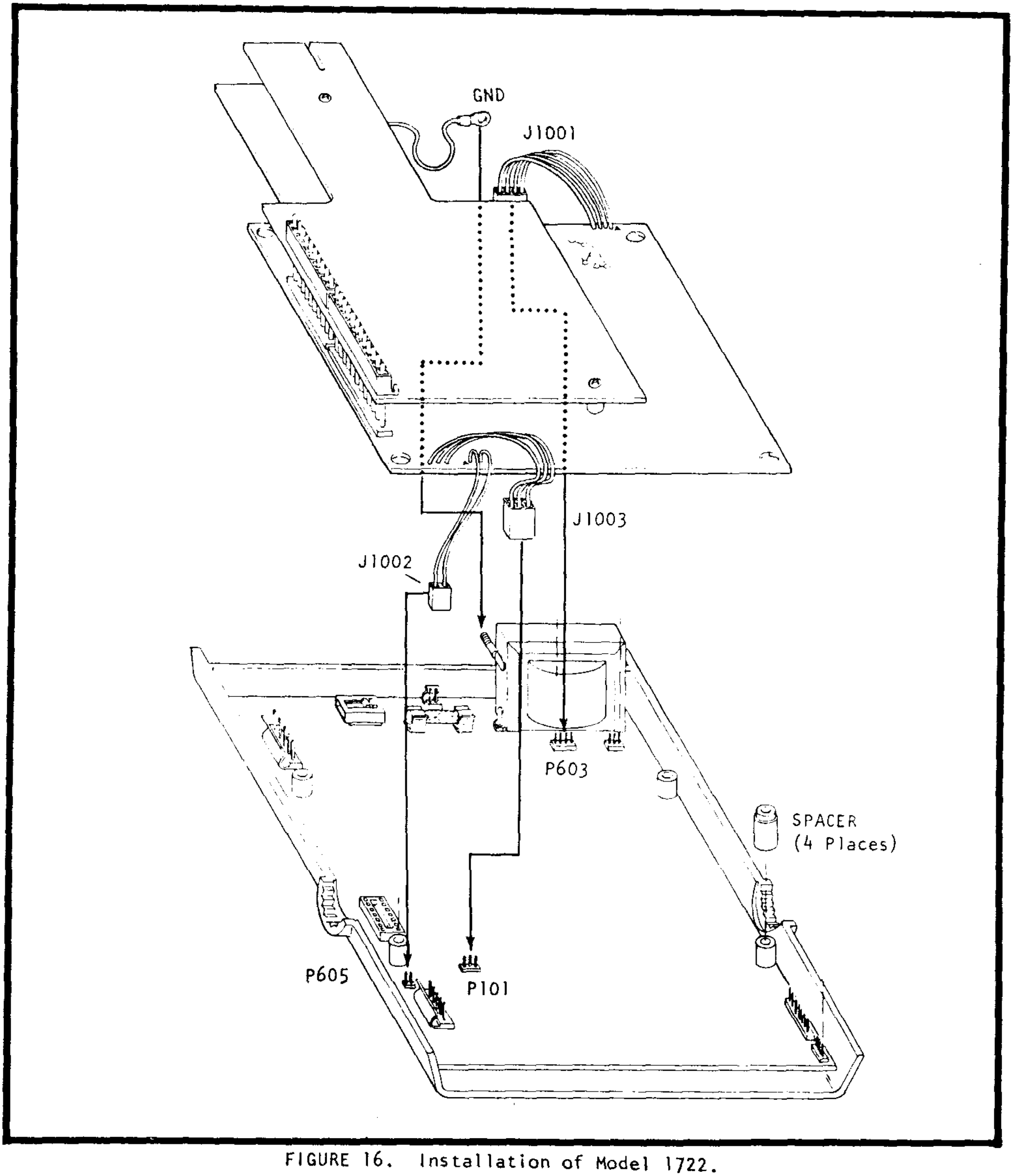


FIGURE 16. Installation of Model 1722.

TABLE 3-6.
Summary of Digital Output at P1006

Pin No.	Signal	Pin No.	Signal
1	CASE GND	21	10^4-2
2	COMMON	22	10^3-1
3	COMMON	23	10^4-1
4	COMMON	24	10^3-1
5	COMMON	25	10^2-8
6	PRINTER HOLD	26	10^1-8
7	AUTOMODE	27	10^2-4
8	VEXT	28	10^1-4
9	R8	29	10^2-1
10	VOLTS	30	10^1-2
11	R4	31	10^2-1
12	AMPS	32	10^1-1
13	R2	33	10^0-8
14	AC	34	$\overline{\text{FLAG}}$
15	R1	35	10^0-4
16	OHMS	36	FLAG
17	10^4-8	37	10^0-2
18	10^3-8	38	OVERFLOW
19	10^4-4	39	10^0-1
20	10^3-4	40	POLARITY

TABLE 3-7.
Summary of Remote Commands at P1101

Pin No.	Command	Pin No.	Command
1	CASE GND*	14	RANGE $\overline{\text{STROBE}}$
2	COMMON	15	R4
3	COMMON	16	POLARITY $\overline{\text{STROBE}}$
4	AUTORANGED $\overline{\text{STROBE}}$	17	R8
5	$\overline{\text{TRIGGER MODE}}$	18	10^4 $\overline{\text{STROBE}}$
6	AUTOMODE $\overline{\text{STROBE}}$	19	TRIGGER
7	HOLD	20	10^3 $\overline{\text{STROBE}}$
8	OVERFLOW $\overline{\text{STROBE}}$	21	$\overline{\text{FLAG RESET}}$
9	$\overline{\text{LOAD}}$ RANGE	22	10^2 $\overline{\text{STROBE}}$
10	FLAG/$\overline{\text{FLAG}}$ $\overline{\text{STROBE}}$	23	$\overline{\text{TRIGGER MODE DISABLE}}$
11	R1	24	10^1 $\overline{\text{STROBE}}$
12	FUNCTION $\overline{\text{STROBE}}$	25	$\overline{\text{AUTORANGED}}$
13	R2	26	10^0 $\overline{\text{STROBE}}$

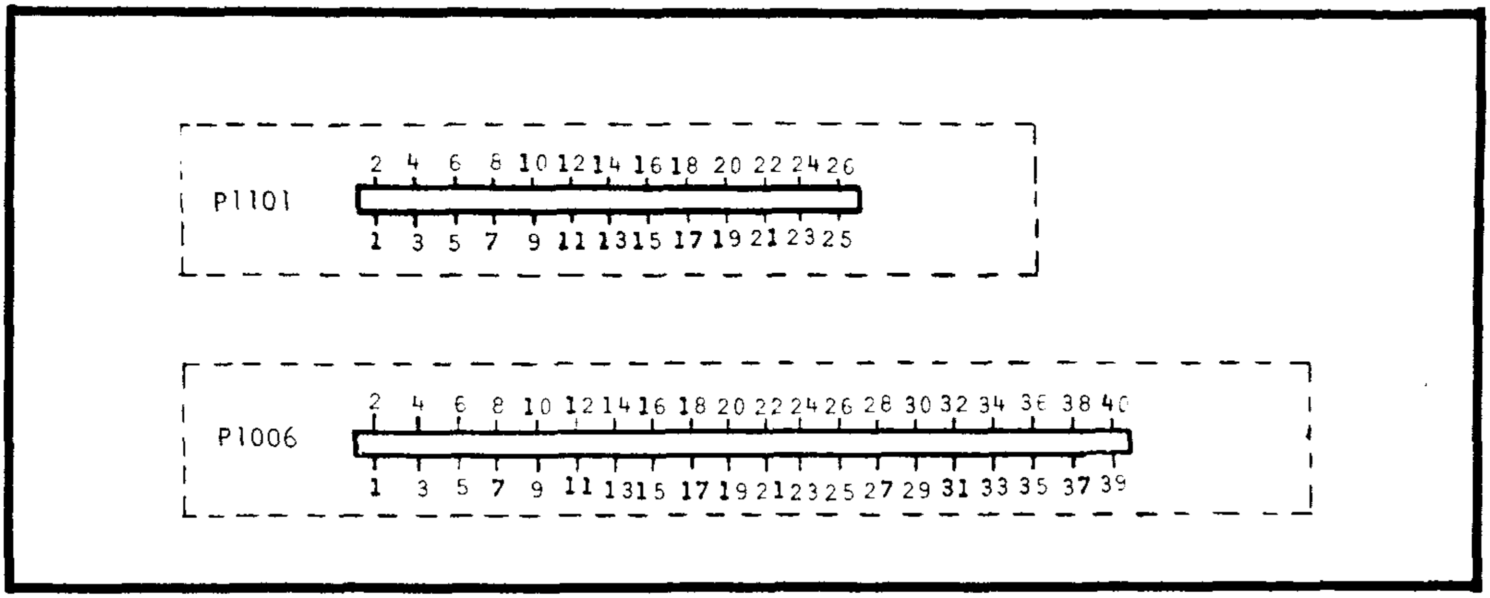


FIGURE 17. Connector Pin Identification for P1006 and P1101.

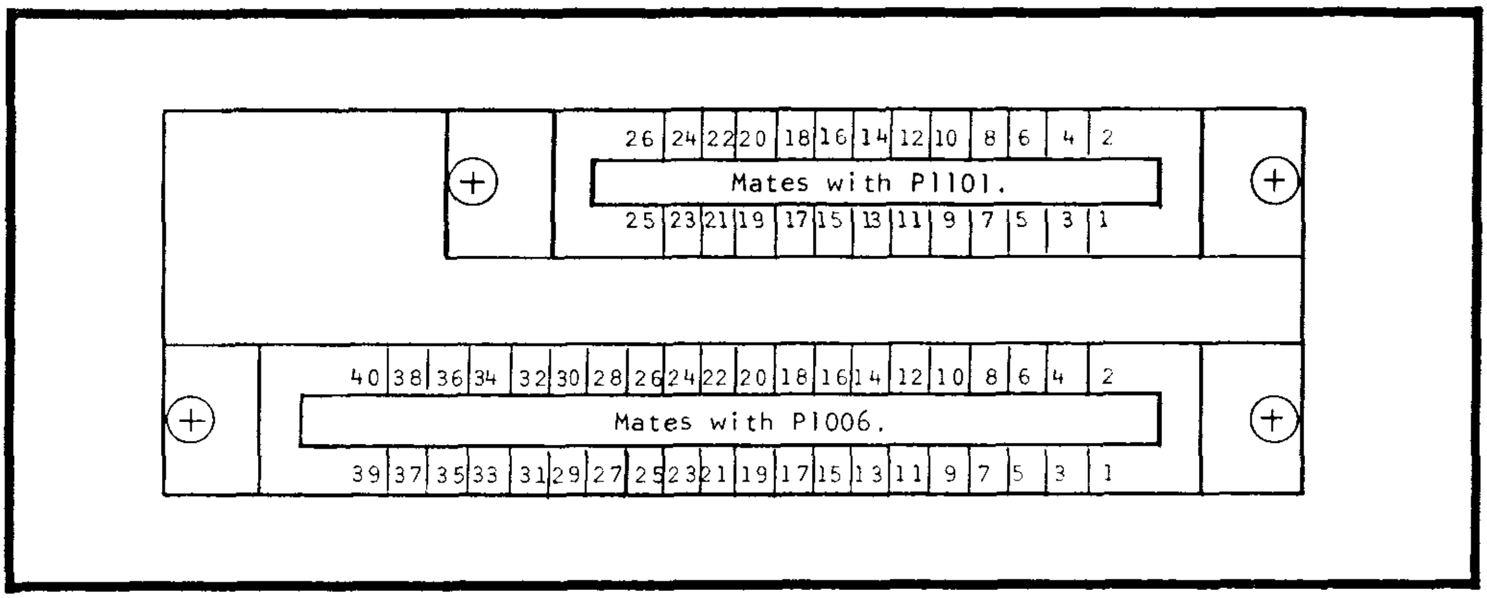


FIGURE 18. Card-Edge Connectors (Model 1727 Cable Set).

d. How to Select Vext Using Internal Jumper. The Model 1722 may be wired for use with internal or external voltage references and internal pull-up resistors. (See Figure 16.)

1. Jumper A. When this jumper is installed, the pull-up resistors are connected to the external reference Vext (pin 8, P1006).

2. Jumper B. When this jumper is installed, the pull-up resistors are connected to the internal reference (+5V).

3. Jumper C. When this jumper is installed, Vext is connected to internal +5V reference. The pull-up resistors are not connected in this instance. The +5 volt reference is rated at 40 mA maximum.

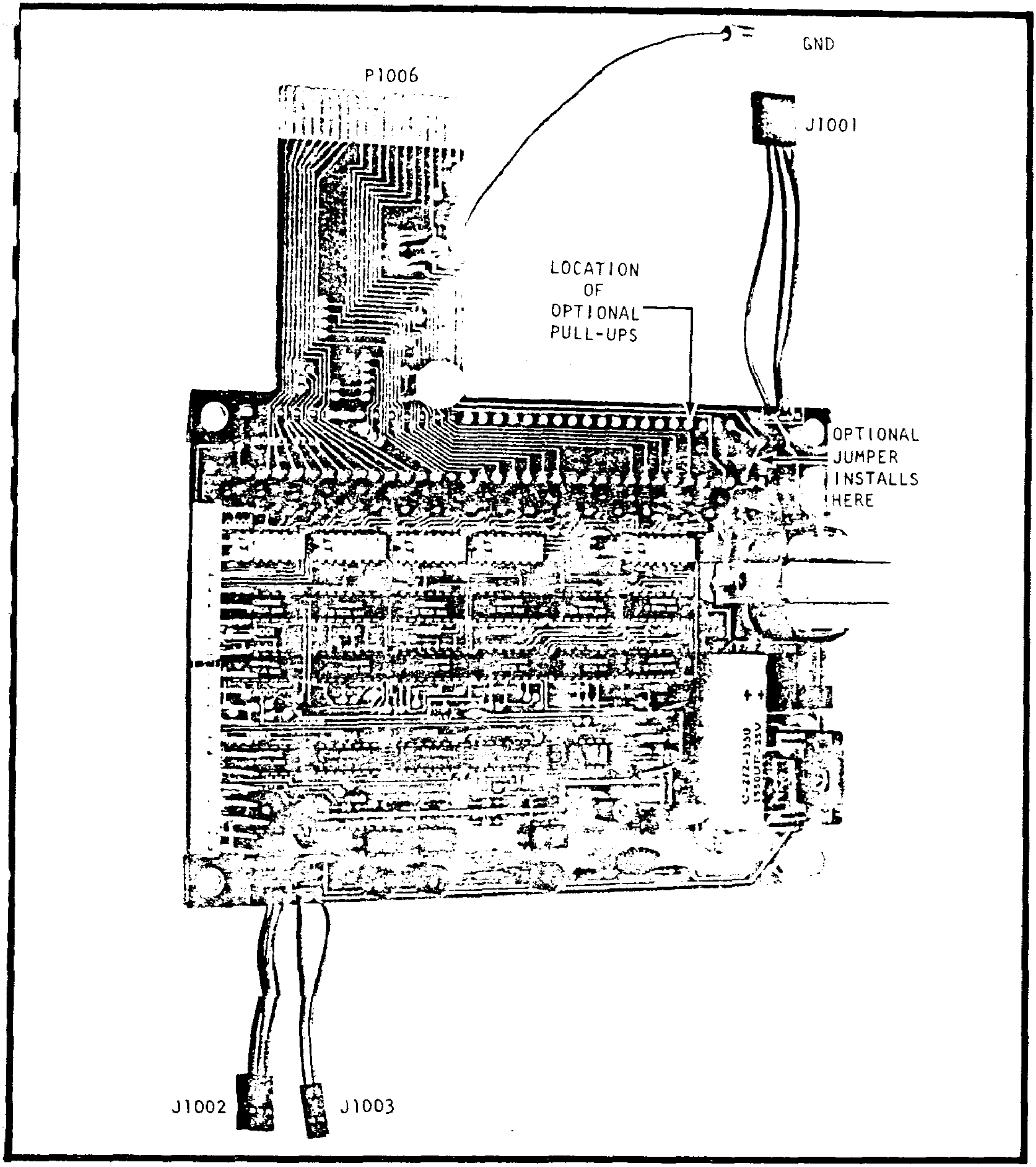


FIGURE 19. Location of Jumpers and Pull-Ups on Model 1722.

TABLE 3-8.
Digital Output Lines Grouped By Function

Name	P1006 Pin No.	P1101 Pin No.
10^0 STROBE	--	26
10^0-1	32	
10^0-2	37	
10^0-4	35	
10^0-8	33	
10^1 STROBE	--	24
10^1-1	32	
10^1-2	30	
10^1-4	28	
10^1-8	26	
10^2 STROBE	--	22
10^2-1	31	
10^2-2	29	
10^2-4	27	
10^2-8	25	
10^3 STROBE	--	20
10^3-1	24	
10^3-2	22	
10^3-4	20	
10^3-8	18	
10^4 STROBE	--	18
10^4-1	23	
10^4-2	21	
10^4-4	19	
10^4-8	17	
POLARITY STROBE	--	16
RANGE STROBE	--	14
-R1	15	
-R2	13	
-R4	11	
-R8	9	

Name	P1006 Pin No.	P1101 Pin No.
FUNCTION STROBE		12
-VOLTS	10	
-AMPS	12	
-AC	14	
-OHMS	16	
OVERFLOW STROBE		8
-OVERFLOW	38	
AUTOMODE STROBE		6
-AUTOMODE	7	
AUTORANGED STROBE		4
-AUTORANGED		25
PRINTER HOLD	6	
TRIGGER MODE		5
HOLD		7
LOAD RANGE		9
R1		11
R2		13
R4		15
R8		17
TRIGGER		19
FLAG RESET		21
TRIGGER MODE DISABLE		23
COMMON	2,3,4,5	2,3
CASE	1	1
FLAG/FLAG STROBE	--	10
FLAG	36	
FLAG	34	
VEXT	8	

TABLE 3-9.
General Characteristics of Model 1722 Digital Interface.

DIGITAL OUTPUTS:
Logic: BCD (8421) Open-collector positive true unless otherwise specified.
Data: 4 full digits, 1 partial digit (0, 1, 2, 3) and exponential range code.

Function: 4-bit code (Ω, AC VOLTS, AMPS)
Polarity: HIGH ≡ +.
Overflow: LOW ≡ > 29999.
Autorange: LOW ≡ range change.
Automode: HIGH ≡ autorange mode.
FLAG (FLAG): HIGH (logic "0" ≡ no output change occuring.
Logic Levels: HIGH ≡ open collector to output LO. LOW ≡ closure to output LO. Output device (2N5134) greater than 20V breakdown, <0.5V at 5mA sink (3TTL loads). Internal pull-up resistors may be installed on these open collector outputs. 4.7K minimum value is recommended when using internal 5 volt power supply.
OUTPUT TIMING: Data is updated typically every 320 msec (non-trigger mode). Update time is typically 1.2 msec. Data will appear at an output only if its respective strobe is active. The FLAG will go low (Logic "0") typically 2 msec before update and go high typically 100 μsec after update. Data can be expected to be unchanging so long as the flag is high. If FLAG RESET is activated, the FLAG will reset (go to Logic "0") until the end of the next data update.
REMOTE CONTROLS:
Strobe: Strobe lines permit word serializing in 4-bit increments or multiples thereof. HIGH inhibits controlled output lines from conduction, LOW enables conduction.
Range In: 4-bit exponential code.
Load Range: Low enables remote ranging as set by Range code.
Hold: LOW inhibits display update, output update and autorange (A/D continues conversions).
Printer Hold: Same as hold but grouped with outputs for convenience in interfacing printer.
Trigger Mode: LOW enables TRIGGER control.
Trigger Mode Disable: LOW disables TRIGGER.
Trigger: LOW to HIGH transition initiates a new A/D conversion.
Flag Reset: LOW sets FLAG (FLAG) to LOW (HIGH).
Control Logic Levels & Source Requirements: HIGH ≡ either an open circuit or a voltage between +2.4V and 5V referred to output LO. LOW ≡ closure to output LO within 0.8V while sinking +1.6 milliamperes (1TTL load). When TRIGGER MODE, HOLD and LOAD RANGE code bits are all HIGH (inactive) the 172/173 is under front panel control. These REMOTE CONTROL inputs have priority and will override any front panel setting once activated.
ISOLATION: All digital outputs and remote controls are isolated from 172/173 analog input by 10^9 Ω and 500pF, 1200 VDC, 1000V rms AC maximum. All digital outputs and remote controls are isolated from chassis ground by 10^6 Ω and 0.01μF; 250V rms maximum.

e. Detailed Explanation of Model 1722.

TRIGGER MODE AND TRIGGER: (See schematic 28248E) — When TRIGGER MODE is active (Low), output data and display will not be updated. TRIGGER MODE enables TRIGGER. Conversion starts within 1.6 milliseconds after TRIGGER. Integration starts 120 milliseconds after start of conversion.

HOLD: — If either HOLD or PRINTER HOLD is low the output data and the display will not be updated and the FLAG will stay at HIGH (unless reset by FLAG RESET).

LOAD RANGE: — When LOAD RANGE is low the 172/173 will go to the range as set by the RANGE IN code (Table 3-10) at the beginning of the next conversion. As long as LOAD RANGE is held low each instrument will remain on its programmed range overriding front panel UPRANGE, DOWNRANGE and AUTORANGE. RANGE IN codes programmed outside the limits of table 3-10 will result in the nearest valid range to that programmed. LOAD RANGE will always cause a DMM range change. However, the display and output data will be held (not updated) during TRIGGER MODE or HOLD.

REMOTE CONTROLS: — Referring to timing schematic 28249D, it is possible to just miss a REMOTE CONTROL update prior to data output. This can be misleading, especially in the case of HOLD. A HOLD just missed (unknown to the user), just before data begins to change, could result in erroneous data. To check if this occurred, it is suggested that the FLAG be examined no sooner than 10 μsec after activation of the HOLD bit. If flag is low wait until it goes to HIGH before expecting the HOLD bit to have been accepted. Other REMOTE CONTROL bits such as TRIGGER MODE and TRIGGER, LOAD RANGE and the RANGE IN code can be kept active for longer than an output data update time, i.e. >3.2 msec to insure proper REMOTE CONTROL acceptance.

TRIGGER MODE DISABLE: (See Schematic 28249D) — When in TRIGGER MODE and triggering into an autoranging condition, normal operation will give an output for each range encountered during the autorange. However, if this is undesirable the AUTORANGED output bit can be tied to TRIGGER MODE DISABLE and FLAG RESET. This will prevent the FLAG from being set and ignore further triggering until the final range is reached.

V_{ext}:	Internal jumpers (user installed) select internal or external voltage reference for user-installed pullup resistors for all open-collector outputs, or applies internal +5V to V_{ext} (maximum external current load on internal +5V is 40mA). Minimum pull-up resistor recommended is 4.7K.
LINE GROUND:	One pin on each output connector.
GROUNDS:	4 pins for digital outputs, 2 pins for remote control.
CONNECTORS:	One 40-pin card edge and one 26-pin card edge.

ENVIRONMENT:

Installed in a 172/173: Operating 0°C to 55°C, humidity 80% @ 35°C.
Storage: -25° to +65°C

f. Modifications to Model 172/173 Specifications. When operating a 172/173 with a 1722 in TRIGGER MODE, only the accuracy specifications for the top two ohms ranges change as follows:

HI Ω 300MΩ Range: From 1% of reading to 1.5% of reading.
HI Ω 30MΩ Range: From 0.15% of reading to 0.2% of reading.

LO Ω 30M Range: From 0.5% of reading to 1% of reading.
LO Ω 3M Range: From 0.1% of reading to 0.15% of reading.

Also when operating in TRIGGER MODE, repeatability of readings may be up to:

0.5% on 300MΩ Hi Ω and 30MΩ Lo Ω ranges, and
0.05% on 30MΩ Hi Ω and 3MΩ Lo Ω ranges.

Accuracy of all other ohms ranges and all other functions is not affected by the Model 1722 when operating in TRIGGER MODE.

TABLE 3-10

MODEL 1722 RANGE & FUNCTION CODING FOR MODEL 172

FUNCTION	OUTPUT FUNCTION CODE (1)	RANGE	OUTPUT RANGE CODE (1)	(EXP)	INPUT RANGE CODE (1) (3)	
	V A AC Ω		R_8 R_4 R_2 R_1		R_8 R_4 R_2 R_1	
DC VOLTS	1 0 0 0				1 1 1 1	AUTORANGE
		300 mV	0 1 0 1	5	1 0 1 0	
		3.0V	0 1 1 0	6	1 0 0 1	
		30 V	0 1 1 1	7	1 0 0 0	
		300 V	1 0 0 0	8	0 1 1 1	
		1200 V	1 0 0 1	9	0 1 1 0	
AC VOLTS	1 0 1 0				1 1 1 1	AUTORANGE
		300 mV	0 1 0 1	5	1 0 1 0	
		3 V	0 1 1 0	6	1 0 0 1	
		30 V	0 1 1 1	7	1 0 0 0	
		300 V	1 0 0 0	8	0 1 1 1	
		1000 V	1 0 0 1	9	0 1 1 0	
DC AMPS	1 0 0 0(2)				1 1 1 1	AUTORANGE
		300 mA	0 1 0 1	5	1 0 1 0	
		2 A	0 1 1 0	6	1 0 0 1	
AC AMPS	1 0 1 0(2)				1 1 1 1	AUTORANGE
		300 mA	0 1 0 1	5	1 0 1 0	
		2 A	0 1 1 0	6	1 0 0 1	
LOW Ω	0 0 0 1				1 1 1 1	AUTORANGE
		300 Ω	0 0 1 0	2	1 1 0 1	
		3 kΩ	0 0 1 1	3	1 1 0 0	
		30 kΩ	0 1 0 0	4	1 0 1 1	
		300 kΩ	0 1 0 1	5	1 0 1 0	
		3 MΩ	0 1 1 0	6	1 0 0 1	
		30 MΩ	0 1 1 1	7	1 0 0 0	
HI Ω	0 0 1 0				1 1 1 1	AUTORANGE
		3 kΩ	0 0 1 1	3	1 1 0 0	
		30 kΩ	0 1 0 0	4	1 0 1 1	
		300 kΩ	0 1 0 1	5	1 0 1 0	
		3 MΩ	0 1 1 0	6	1 0 0 1	
		30 MΩ	0 1 1 1	7	1 0 0 0	
		300 MΩ	1 0 0 0	8	0 1 1 1	

(1) Coding in this table is defined to be HIGH (POSITIVE) TRUE. "1" = HIGH and "0" = LOW. Refer to output and remote control logic levels for definitions of HIGH & LOW.

(2) Function code for Model 172 current is volts.

(3) Note that except for AUTORANGE CODE, INPUT & RANGE CODE is the compliment of the OUTPUT RANGE CODE, i.e. the INPUT RANGE CODE is the LOW TRUE BCD code of (EXP).

TABLE 3-11

MODEL 1722 RANGE & FUNCTION CODING FOR MODEL 173
(Same as Table 3-10 except as follows)

FUNCTION	OUTPUT FUNCTION CODE (1)	RANGE	OUTPUT RANGE CODE (1)	(EXP)	INPUT RANGE CODE (1) (3)
	V A AC Ω		R_8 R_4 R_2 R_1		R_8 R_4 R_2 R_1
DC AMPS	0 1 0 0				1 1 1 1 AUTORANGE
		300 µA	0 1 0 1	5	1 0 1 0
		3 mA	0 1 1 0	6	1 0 0 1
		30 mA	0 1 1 1	7	1 0 0 0
		300 mA	1 0 0 0	8	0 1 1 1
		3 A	1 0 0 1	9	0 1 1 0
AC AMPS	0 1 1 0				1 1 1 1 AUTORANGE
		300 µA	0 1 0 1	5	1 0 1 0
		3 mA	0 1 1 0	6	1 0 0 1
		30 mA	0 1 1 1	7	1 0 0 0
		300 mA	1 0 0 0	8	0 1 1 1
		3 A	1 0 0 1	9	0 1 1 0

3-13. COMMENTS RELATIVE TO THE MODEL 172/173 SPECIFICATIONS. Above 1 ampere there is a decrease in accuracy. This decrease in accuracy is due to self heating and the temperature coefficient of the resistors that are used in these currents. This degradation in accuracy will not exceed those values that are listed in the specification sheet. However, prolonged operation at the high currents (for instance, 2 amperes on the Model 172, or 3 amperes on the Model 173) may give temporary zero shifts because of the thermals which are generated due to the self heating of the devices. AC voltage specifications are listed down to 1% of range. Below 1% of range an additional 10 digits is added to the accuracy. This does not occur immediately at the 1% level, but gradually as the level is decreased, because the zero of the ac/dc converter is not very well defined. It has to overcome the threshhold level of various semiconductor devices (a MOS FET and diode). As a result there will typically be a 10 digit offset at zero even with the input shorted on the 300 millivolt range and on the 30 volt range. The 30 volt range offset will be somewhat smaller because the noise will be somewhat less. For best accuracy use the Model 172/173 on whatever range gives the largest reading. Autoranging will accomplish this automatically.

3-14. MODEL 1728 OPERATING TIPS. Although the manufacturers of the nickel cadmium batteries used in the 1728 claim that their cells can be charged at a C/10 rate indefinitely, once a cell is fully charged, the energy fed to the cell is converted to heat, which increases the temperature of the cell. If cells are overcharged at C/10 rate for extended periods of time (weeks), this may cause cell degradation. Keithley recommends that the 1728 not be overcharged for extended periods to maximize useful battery life. Trickle charging should have no effect on useful battery life. Nickel Cadmium batteries also exhibit a memory effect. If the 1728 is only used to operate the instrument for relatively short periods of time (1 or 2 hours) the 1728 may not be able to provide the full operating time of 6 hours.

Do not operate the Multimeter in BAT mode after the LO BAT indicator is lighted. The discharge characteristic of Nickel Cadmium batteries is such that it maintains a fairly constant 1.2V through most of its discharge cycle. At the end of the discharge curve the cell voltage drops fairly rapidly to zero volts. After a given cell in the battery pack drops to zero it is reverse charged by the rest of the cells in series with it. Although the cells used in the 1728 are guaranteed by the manufacturer to withstand reverse charge for 10% of their discharge time, it is not a good practice to continually reverse charge cells, as more rapid cell degradation may occur.

The cells used in the 1728 should give a minimum of 250 discharge/charge cycles and typically 500 discharge/charge cycles. Thus, based on daily useage (5 day week, one per day) the battery pack should give a minimum of one year operation and typically two years. Longer life should be expected for less frequent useage.

TABLE 3-12

Summary of Fuses and Miscellaneous Replaceable Parts

ITEM	WHERE USED	KEITHLEY PART NO.
Fuse, 3 AB/3 AG, 1/4 A, Slo-Blo	117V Line Volts	FU-17
Fuse, 3 AB/3 AG, 1/8 A, Slo-Blo	234V Line Volts	FU-20
Fuse, 3 AB/3 AG, 1 A, Slo-Blo	Model 1728	FU-10
Fuse, 3 AB/3 AG, 2 A Quick	Model 172 Amperes	FU-13
Fuse, 3 AB/3 AG, 3 A Quick	Model 173 Amperes	FU-2
Top Cover (less metalcal)	-	27979C
Bottom Cover (less metalcal)	-	25727E
Handle (less insert)	-	25729D
. . Insert	-	26090A
Rubber Foot	-	FE-10

SECTION 4. ACCESSORIES

4-1. GENERAL. This section describes the various accessories and options available for use with the Model 172/173 Digital Multimeter.

4-2. POWER OPTIONS. The Model 172/173 can be powered by line voltage (105-125V standard) or rechargeable Battery Pack (Model 1728). Other line voltage ranges are available as described in Section 2. The Model 1728 is available factory-installed or field-installable.

4-3. ISOLATED DIGITAL OUTPUT. The Model 1722 Digital Output Interface is available factory-installed or field-installable. Complete specifications are given in Section 3 (paragraph 3-12.)

IMPORTANT

The Model 1722 and 1728 cannot be installed and used at the same time since both options occupy the same location on the Model 172/173 chassis.

4-4. RACK MOUNTING. THE Model 172/173 can be rack mounted in a full rack (19 inch width) in either a single or dual mounting configuration.

MODEL 1010 SINGLE RACK MOUNTING KIT

Description:

The Model 1010 is a single rack mounting kit with overall dimensions 5-1/4 in. (133 mm) high and 19 in. (483 mm) wide. The hardware included in this kit includes a 19 inch wide panel and other miscellaneous hardware.

Application:

The Model 1010 adapts one Keithley Style "K" instrument for Standard 5-1/4 in. (133 mm) x 19 in. (483 mm) rack mounting with 11 in. (280 mm) depth behind the front panel. For dual rack mounting of Style "K" instruments the Model 1017 Dual Rack Mounting Kit must be used.

Parts List:

Item No.	Description	Qty Req'd	Keithley Part No.	Illustration
1	Front Panel	1	26595D	
2	Support Plate (Shelf)	1	26599C	
3	Bracket, Left Side	1	26600B	
4	Bracket, Right Side	1	26601B	
5	Slotted Screw, #6-32 x 2-1/4 in.	2	--	
6	Flat Washer, #6	2	--	
7	Phillips Screw, #8-32 x 1/2 in.	10	--	

Assembly Instructions:

1. Using two Phillips Screws (Item 7) attach Support Plate (Item 2) to Front Panel (Item 1).

2. Using four Phillips Screws (Item 7), attach left and right side Brackets (Items 3 and 4) to Front Panel (Item 1).

3. Using four Phillips Screws (Item 7), secure left and right side Brackets to Support Plate (Item 2).

4. Assembly of rack hardware is complete except for mounting of Instrument.

5. Rotate "handle" of Instrument so that handle is toward rear of Instrument. (Handle can be removed completely if desired by separating top and bottom covers.)

6. Remove two Slotted Screws (1-1/4 in. long) used to hold top and bottom covers together near front feet.

7. Position Instrument so that holes in bottom of Instrument align with two front holes on Support Plate.

8. Using two Slotted Screws (Item 5) and two Flat Washers (Item 6), secure Instrument to Support Plate.

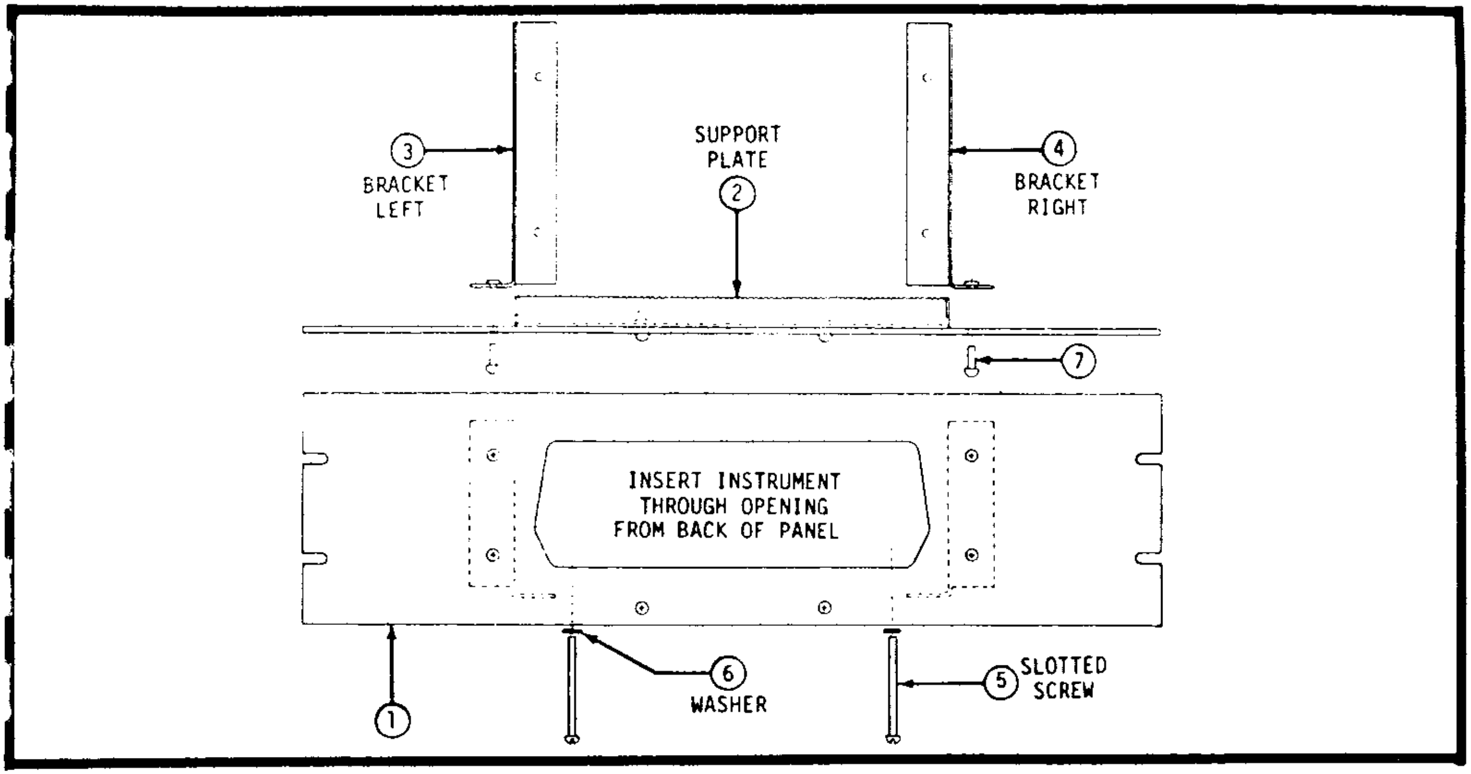


FIGURE 20. Model 1010 Single Rack Mounting Kit.

MODEL 1017 DUAL RACK MOUNTING KIT

Description:

The Model 1017 is a single/dual mounting kit with overall dimensions 5-1/4 in. (133 mm) high and 19 in. (483 mm) wide. The hardware included in this kit includes a 19 inch wide panel, and other miscellaneous hardware.

Application:

The Model 1017 adapts two Keithley Style "K" instruments for Standard 5-1/4 in. (133 mm) x 19 in. (483 mm) rack mounting with 11 in. (280 mm) depth behind the front panel.

Parts List:

Item No.	Description	Qty Req'd	Keithley Part No.	Illustration
1	Front Panel	1	28092D	
2	Support Plate (Shelf)	1	28094C	
3	Bracket, Left Side	1	28096B	
4	Bracket, Right Side	1	28097B	
5	Slotted Screw, #6-32 x 2-1/4 in.	4	--	
6	Flat Wasner, #6	4	--	
7	Phillips Screw, #8-32 x 1/2 in.	4	--	
	Blank Cover Plate	1	28098B	
8	Hole Plug	2	HP-20	
9	Kep Nut, #8	5	--	

Assembly Instructions: (See Figure 21, page 4-4.)

1. Using four Phillips screws (Item 7) attach left and right hand Side Plates (Items 3 and 4) to the Support Plate (Item 2).
2. Using three Kep Nuts (Item 9) attach the Support Plate (Item 2) to Front Panel (Item 1).
3. Fasten the Side Plates to the Front Panel using two additional Kep Nuts (Item 9).
4. Assembly of rack hardware is complete except for mounting of the Instrument(s).
5. The plastic tilt bail/handle on each instrument must be removed before mounting. The top and bottom covers of the instrument must be disassembled in order to remove the handle. Loosen four screws on the bottom cover of the instrument, lift off the top cover, and remove handle. Replace the top cover and tighten the four screws on the bottom cover.
6. Remove two Slotted Screws (1-1/4 in. long) used to hold top and bottom covers together near the front feet on each instrument. These screws are captive and a needle-nose pliers should be used to pull the screw out after it is loosened with a screwdriver.
7. Position the Instrument so that holes in the bottom of the Instrument align with the two front holes in the Support Plate.
8. Using two Slotted screws (Item 5) and two Flat Washers (Item 6) secure the Instrument to the Support Plate.

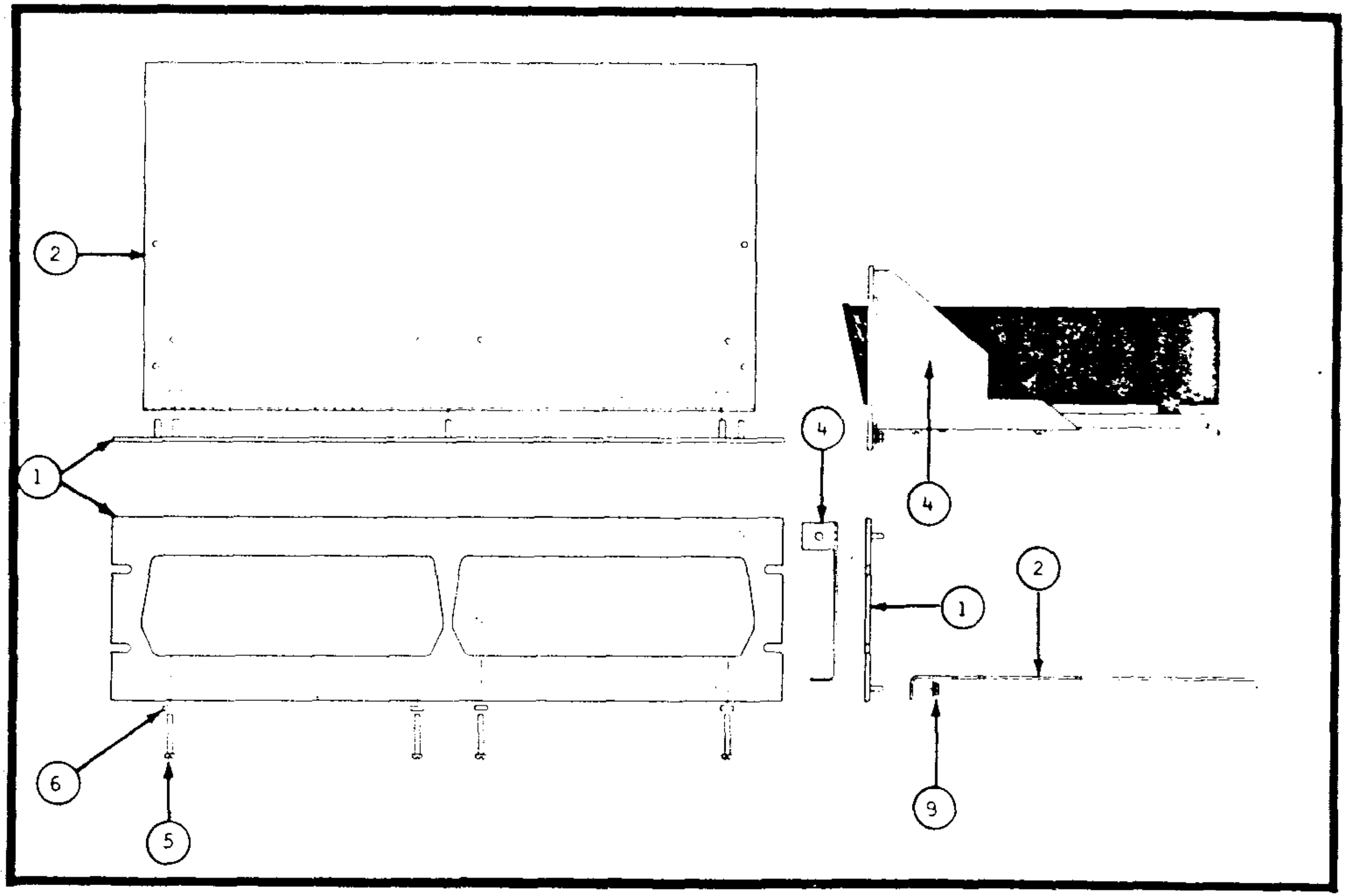


FIGURE 21. Model 1017 Dual Rack Mounting Kit.

4-5. PROBE AND SHUNTS. The following probes and shunts extend the capabilities of the Model 172/173.

MODEL 1600 HIGH VOLTAGE PROBE

Description: The Model 1600 is a divider probe for measurement of high voltage up to 40 kilovolts dc. The probe is optimized for use with a dc voltmeter having 10 megohms input resistance.

MODEL 1682 RF PROBE

Description: The Model 1682 is an RF probe for measurement up to 100 MHz. The Model 1682 is optimized for use with a dc voltmeter having 10 Megohms input resistance.

MODEL 1685 CLAMP-ON AC CURRENT PROBE

Description: The Model 1685 is a clamp-on current probe for measurement of ac current up to 200 amperes. The Model 1685 is used with an AC voltmeter and provides an output of 0.1 volt rms per ampere.

MODEL 1651 CURRENT SHUNT

Description: The Model 1651 is a 0.001 ohm shunt for use with an AC or DC voltmeter having at least 100 microvolts resolution. The shunt is rated at up to 50 amperes.

4-6. CABLES AND CONNECTORS. The following cables and connection Kits enable effective use of the Model 172/173.

MODEL 1683 UNIVERSAL TEST LEAD KIT

Description: The Model 1683 is a set of flexible test leads, 40 in. (1m) in length, with interchangeable screw-on adapters.

MODEL 1681 CLIP-ON TEST LEAD KIT

Description: The Model 1681 is a set of test leads, 48 in. (1,2m) in length, terminated by a banana plug and spring-action clip-on probe.

MODEL 1727 DIGITAL OUTPUT CABLE SET

Description: The Model 1727 is a cable set consisting of 26- and 40- conductor ribbon cable terminated by mating card-edge connectors to the model 1722. The Model 1727-3 is 3 feet long (1 m), and the Model 1727-10 is ten feet long (3,1 m).

MODEL 7004 SHIELDED CABLE

Description: The Model 7004 cable is a shielded cable, 42 inches (1,1 m) long and is terminated by 2 tinned leads plus shield. Two banana plug adapters are furnished for use with Models 172/173.

Application: The Model 7004 cable is useful when making low-level voltage connections to the Model 702/7029 Low-Voltage Scanner, both analog INPUT and OUTPUT. The shield may be connected to the GUARD terminal.

4-7. MISCELLANEOUS.

MODEL 1725 MAINTENANCE KIT

Description: The Model 1725 contains a specially punched calibration cover for accessability to adjustment controls on the Model 172/173 chassis.

MODEL 702/7029 LOW-VOLTAGE SCANNER

Description: The Model 702/7029 is a ten-channel low-voltage scanner. The 702/7029 can be used for manual, scan, or remote scanning operation.

CHANNELS: 10 channels per scanner mainframe (multiple scanner mainframes may be connected for up to 100 channels).

CONTROL MODES (FRONT PANEL SELECTABLE):

All-Off: No Channel selected.

Manual: Channel selected by front panel switch.

Scan: Channels sequentially selected at a rate determined by front panel control. Initial channel may be preset.

Remote: Channel randomly selected using 4-line BCD code, or sequentially selected at remote clock rate.

SCAN RATE: Variable from nominally 0.1 to 10 seconds per channel by front panel control. Scan rate using remote clock is limited only by relay closure time.

DISPLAY: Single digit front panel LED display identifies channel selected.

DIGITAL INPUT AND DIGITAL OUTPUT: TTL interface lines provide for remote channel selection, clock, and control of All-Off mode. Output data includes present channel address, mainframe identification, clock, and relay ready. The (digital) Common may be floated up to ±30 volts peak with respect to (chassis) Ground.

ENVIRONMENT: 0°C-50°C, 0% to 80% relative humidity up to 35°C.

POWER: 90-125 or 200-250 volts (switch selected), 50-60Hz, 15 watts.

CONNECTORS:

Digital Input, Digital Output (rear): 26-pin 3M Part No. 3429-1002.

Common, Ground (rear): Binding posts.

Scanner Plug-in Card (rear): Internal connector mates with plug-in card edge.

Analog Inputs, Output, and Guard (rear): Clamp-type barrier strips for use with # 14 to 22 AWG wire.

Scanner Mainframe: Card edge mates with Scanner Mainframe internal connector.

SIGNAL INPUTS: 10 channels per card.

SWITCHING CONFIGURATION: Guarded, 2-pole, break before make.

RELAY CLOSURE TIME: Less than 5 milliseconds.

EXPECTED LIFE: 10^8 closures per channel.

SIGNAL LEVEL: 10 volts peak, 10 milliamperes peak with a resistive load for expected life. Absolute maximum peak instantaneous ratings: 200 volts, 100 milliamperes, or 2 volt-amperes with a resistive load.

THERMAL OFFSET (LABORATORY ENVIRONMENT): Less than 3 microvolts from input to output when copper wires are used.

SIGNAL PATH RESISTANCE: Initially less than 0.5 ohm per pole; less than 2 ohms at end of life.

ISOLATION: Guarded interchannel resistance is nominally 10^{12} ohms at room temperature, and guaranteed greater than 10^{10} ohms at environmental extremes. Unguarded capacitance is less than 10 picofarads between any two signal terminals.

GUARDING: Guard surrounds all analog signal paths. Each 10-channel scanner plug-in card in multi-scanner systems may have a separate guard voltage.

MAXIMUM LEVELS: 200 volts peak between signal line pairs or from signal lines to guard or Mainframe (digital) Common. 100 volts peak between guard and Mainframe (digital) Common.

DIMENSIONS, WEIGHT: Style M 3-1/2 in. half-rack, overall bench size 4 in. high x 8-3/4 in. wide x 15-1/4 in. deep (100 x 220 x 385 mm). Net weight 8 pounds (3.5 kg).

ACCESSORIES SUPPLIED: Model 7021-2 System Interconnect Cable.

ACCESSORIES AVAILABLE:

Model 7021-2 System Interconnect Cable: 2 foot (0,6m) cable interconnects scanners for multiple-scanner operation (n-1 used for interconnecting n scanners). 40 foot (12m) maximum recommended total system cable length (extra).

MODEL 750 PRINTER WITH MODEL 7501-1722 PRINTER INTERFACE

Description: The Model 750 is an 18-column printer which is plug-to-plug compatible with the Model 172/173.

COLUMNS: 18 (see Drum Diagram).

DECIMAL POINT: 13 decimal points; 9 are floating and print to right of number (columns 6 through 10, 12 through 15).

FRONT PANEL CONTROLS: Power; Run; Manual Print; Paper Feed; Print Interval.

PRINT RATE: Print Interval control provides intervals from 1 sec./line to 10 sec./line, continuously adjustable. In the External position, up to 2½ print commands/sec. are accepted.

DATA INPUT: Parallel BCD (8421) high true (low true with removal of jumper). Floating decimal points are low true only.

Compatible Logic: TTL, DTL or open collector; inputs are 2 TTL loads (floating decimal points, 1 TTL load).

CONTROL INPUTS: External Print; Red Print; Motor Off; Remote Standby; Continuous Print; Inhibit.

Compatible Logic: TTL, DTL or open collector; inputs are 2 TTL loads (External Print and Continuous Print, 3 TTL loads). Inputs are low true, except External Print requires low-to-high transition.

CONTROL OUTPUT: Printer-in-Cycle (PIC); End-of-Print Data Hold; Manual Print; Print Twice.

Output Logic: TTL, can drive 8 TTL loads (PIC, 4 TTL loads). Outputs are high true; except End-of-Print is 3ms pulse, Printer-in-Cycle and Data Hold are low true.

INPUT/OUTPUT (I/O) CONNECTIONS: Two 50-pin recessed card-edge connectors; I/O A for data input, columns 1 through 10; I/O B for accessories and/or additional data, columns 11 through 18 (see Drum Diagram).

ISOLATION: Input Lo to chassis ground greater than 10^7 ohms. Lo may be floated up to 350 volts peak with respect to chassis ground.

PAPER: 2¼ in. fan-fold or roll.

RIBBON: Black/red, ½ in. wide.

ENVIRONMENT: 0°C to 50°C, 0% to 80% relative humidity at up to 35°C.

POWER: 90-110, 105-125, 200-240 volts (switch selected), 50-60 Hz, 30 watts (40 watts with accessories).

DIMENSIONS, WEIGHT: Style 0, 7 in. half-rack, overall bench size 7½ in. high x 8½ in. wide x 15¼ in. deep (190 x 220 x 390 mm). Net Weight, 16 pounds (7 kg).

ACCESSORIES FURNISHED: One ribbon (installed), one pack fanfold paper.

SECTION 5. THEORY OF OPERATION

5-1. GENERAL. This section contains circuit description information for the Model 172/173. The description is broken down into the following major categories.

a. Input Signal Conditioning.

b. Power Supply

c. Display Board

d. Durrent Board

e. Battery Pack (Model 1728).

f. A/D Converter

g. Digital Interface (Model 1722).

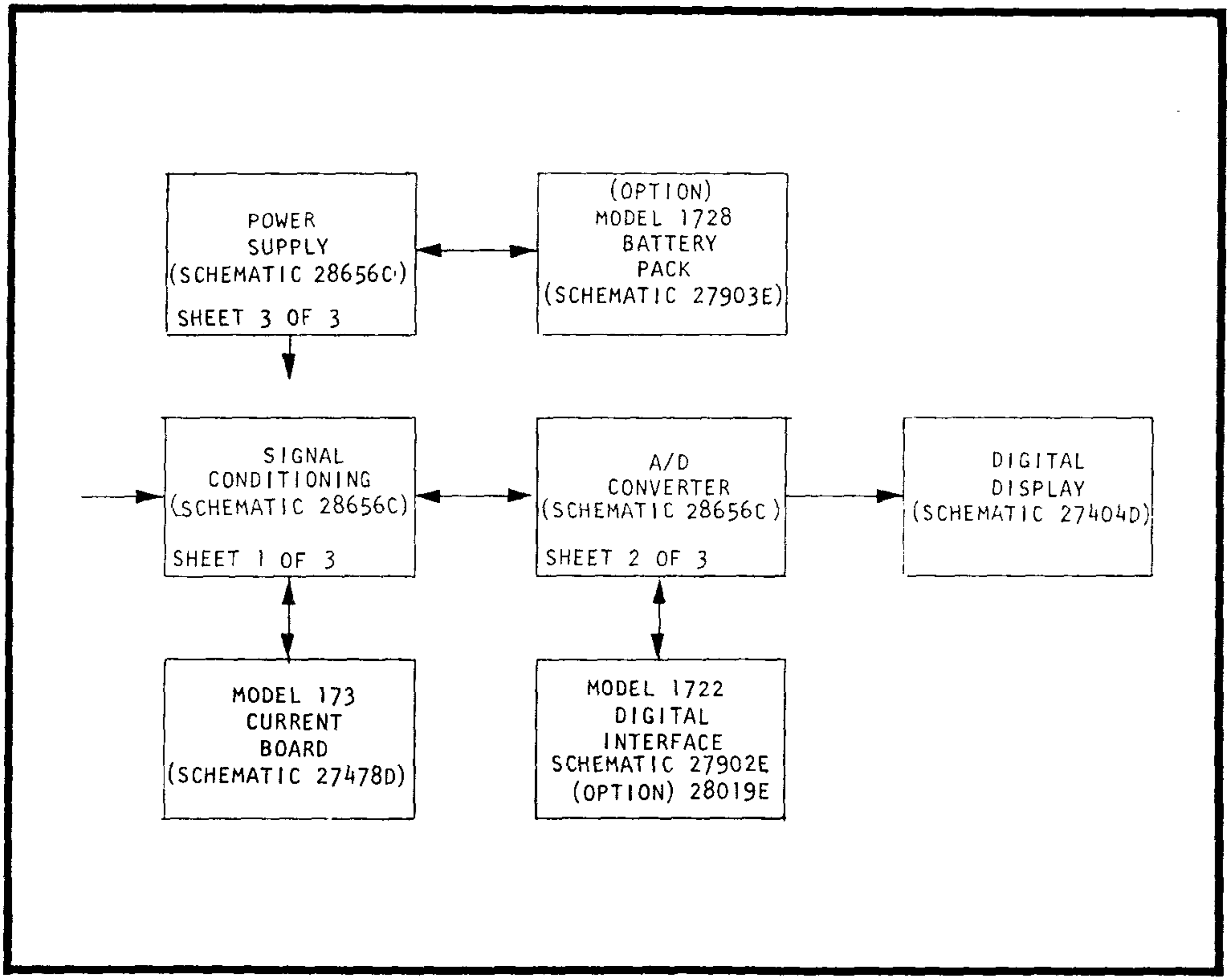


FIGURE 22. Overall Block Diagram of Model 172/173.

5-2. INPUT SIGNAL CONDITIONING. (Schematic 27903E). This circuit consists of input switching, overload protection, ohms converter, ac/dc converter, and filter.

a. Switching. The interlocked pushbutton switches set the DMM to the appropriate function. Table 5-1 summarizes the switching scheme.

TABLE 5-1.
Summary of Pushbutton Switching

Switch	Style	Setting	Remarks
Line	Push-Push	In	DMM is powered by ac line power. Battery pack (if installed)has a trickle charge.
Line	Push-Push	Out	DMM is disconnected from line power. Battery pack (if installed) is charged at maximum rate if line cord is connected to power.
BAT	Push-Push	IN	DMM is powered by internal Battery Pack.
BAT	Push-Push	Out	DMM is disconnected from Battery Pack. NOTE Interlock prevents both pushbuttons IN at the same time. Both pushbuttons must be set to OUT before either can be set to IN. Push-Push means that a single depression will place the pushbutton to IN, a second depress-oon will release the pushbutton to OUT.
AUTO/MAN	Push-Push	In	DMM is set to MAN (Manual mode). To change range depress either DN RANGE or UP RANGE. See also REMOTE PROGRAMMING OPTION.
AUTO/MAN	Push-Push	Out	DMM is set to AUTO (Automatic Ranging Mode.) DMM range is set automatically
DN Range	Momentary	In	Momentary depression causes the DMM to down range one decade to lesser sensitivity. Operable only when AUTO/MAN is IN.
UP Range	Momentary	In	Momentary depression causes the DMM to up range one decade to greater sensitivity. Operable only when AUTO/MAN is IN.
DC **	*Interlock	In	DMM is set to DC mode. Overrides AC and Ω functions due to interlocked pushbuttons.
AC	*Interlock	In	DMM is set to AC mode. Overrides DC and Ω functions due to interlocked pushbuttons.
Ω**	*Interlock	In	DMM is set to Ω mode. Overrides AC and DC functions due to interlocked pushbuttons, also overrides V/A switch.

TABLE 5-1 (Continued)
Summary of Pushbutton Switching

Switch	Style	Setting	Remarks
** Can be depressed and held IN simultaneously			*NOTE If DC, AC, and Ω pushbuttons are OUT simultaneously, no function will be selected, the input terminals will be open-circuited, and the DMM will display Ω. The displayed reading is meaningless.
V/A	Push-Push	In	DMM is set to measure current (either AC or DC). Not functional when set to Ω.
V/A	Push-Push	Out	DMM is set to measure voltage (either AC or DC).
HI/LO***	Push-Push	In	DMM is set to low ohms range. **
HI/LO***	Push-Push	Out	DMM is set to high ohms range. ** ***Note Only functional when set to Ω.
2 WIRE/4 WIRE***	Push-Push	In	DMM is set for 4-WIRE ohms measurements. Upper pair of terminals are used for voltage sensing. Lower pair of terminals are used for ohms source. Lower pair of terminals are useable only in 4 WIRE Ω mode and are open circuited for all other conditions.
2 WIRE/4 WIRE***	Push-Push	Out	DMM is set for conventional 2-WIRE ohms measurements. Upper pair of Terminals must be used. Lower pair of terminals are open-circuited.

TABLE 5-2.
Gain Chart For AC/DC Voltage

RANGE	ATTENUATION	A/D GAIN	RANGE CONTROL LINES RL	H
300 mV	÷1	X10	+8 V	-12 V
3 V	÷1	X1	+8 V	-12 V
30 V	÷100	X10	0 V	-12 V
300 V	÷100	X1	0 V	-12 V
1000 V	÷1000	X1	0 V	-8 V

b. DC Volts Input Circuit.

1. DC Volts input circuitry is used to attenuate the input if necessary and filter out unwanted AC signals. A combination of attenuation and A/D converter gains allows five ranges of DC Volts. See Table 5-2 on page 5-3.

2. There is no attenuation on the 300 m V and 3 V ranges. Relay K901 (Figure 23) is shown in this position. The attenuator is bypassed which allows the input resistance of greater than 10^9 ohms.

3. Above 3 volts, relay K901 switches in the attenuator. There are two attentuation levels, ÷100 with FET switch Q901 off and ÷1000 with Q901 on. C901 assures AC attenuation of at least ÷1000 so that normal mode rejection is maintained. RL line controls K901 and line controls Q901 (See table 5-2).

4. Overload protection is assured by the clamp circuit, R929, and C907. If a large voltage is applied on the 300 m V or 3 V ranges, the clamp limits the voltage to ±5 V after R929. R929 absorbs the input voltage. As the relay switches in the attenuator, C907 keeps the relay voltage from becoming large enough to cause arcing or plazma effects. The clamp is essentially an open circuit between ±5 Volts.

. Filtering Circuit.

1. The DC filter is used in front of the A/D Converter on all functions. It is a 3-pole active filter with 3 db frequency of 5Hz and a settling time of less than 300 ms to within 0.01%. It requires an input resistance of 200KΩ, 49.9KΩ of which is R918. The other 150KΩ comes from various sources in the following manner:

In DC Volts, 300 m V and 3 V range: R929,
30 V and 300 V range: R919 + R908 + R911+R910
In AC Volts, all ranges: R801
In Ω , all ranges: R928

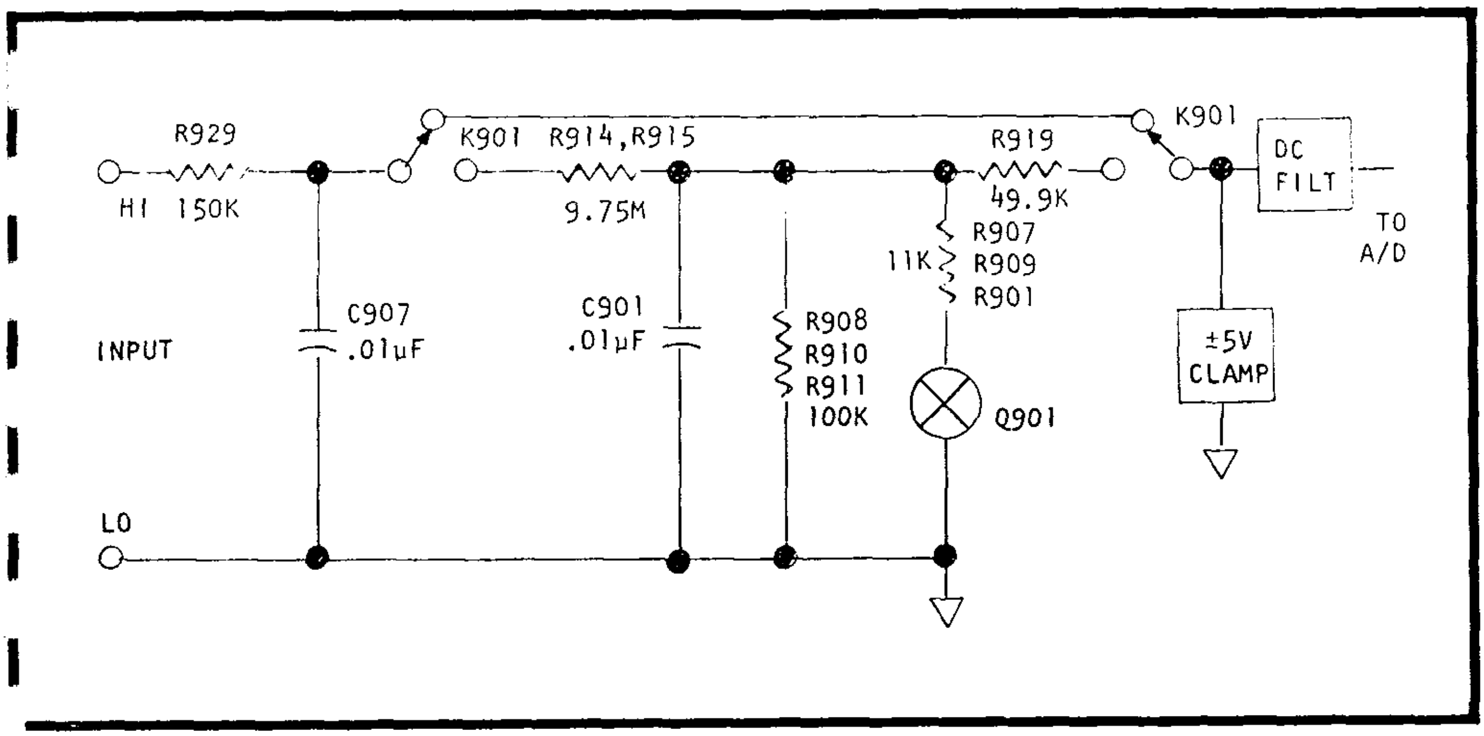


FIGURE 23. DC Volts Input Circuit.

This 200KΩ is also maintained so that the effect of A/D input current is autozeroed out (See A/D discussion, section 5-7). The DC filter contributes no DC offsets to the signal path. They are blocked by C905 & C904. R922, R917, C902 & U901 complete the filter circuit. R921 is a current limiting resistor and C903 frequency compensates U901.

d. AC Attenuator.

1. AC voltages are first attenuated if necessary, converted from AC to DC, then filtered and passed on to the A/D converter.

2. The AC attenuator (Figure 24) is really a frequency compensated summing amplifier with maximum gain of unity. Its other gains are ÷100 and ÷1000 which are switched by relay K801 and FET Q804 respectively. RL line controls K801 and H line controls Q804 (see table 5-2).

3. C908 blocks DC signals up to ±1000V, so that AC signals may be looked at in the pressure of DC voltages. The attenuator is referenced to -6 Volts to keep the DC bias voltage on C808 and C809 (figure 25) near zero.

4. The gain of the attenuator is $\frac{-Zf}{Z\,IN} = \frac{-Rf\,(1+j\omega RiCi)}{Ri\,(1+j\omega RfCf)}$. By making the RC time constant of Zf equal to the RC time constant of Z IN, the gain of the attenuator is constant with frequency, and equal to $\frac{-Rf}{Ri}$. This is true in the midband region. Low frequency is limited by RC time constant of C908 and RIN (R818) and high frequency by U803. Nominal values of resistance and capacitance are shown in Figure 24.

5. Amplifier U803 is powered from +3 V and -15 V. When overloaded the average voltage at the output is -6 Volts which keeps DC voltage off of C808 and C809. This minimizes settling time when autoranging.

e. AC Converter.

1. The AC converter is a transconductance amplifier. The simplified circuit shows the basic operation. The AC input voltage (Ein) is converted to a current (Iin) because of the summing amplifier configuration. This current flows through the FET when negative and through the diode when positive. Thus Eout is a half wave rectified signal if the polarity is negative. Eout is the input current flowing through Rout. The + terminal of the converter amplifier is referenced to a negative voltage to allow voltage swing across the FET (Q801).

2. The ac converter consists of dual FET Q803, operational amplifier U801 and MOSFET Q801, diode CR801, and transistor Q802, semiconductor elements. The input resistance is R812 and R807, and the output resistance is R802 in series with R803 adjustment pot. FET Q801 is located in the feedback loop of the converter amplifier and the gate of this FET is driven from the output of the amplifier for one polarity.

3. For the other polarity the feedback path for U801 and input FETs Q803 (a,b) is through diode CR801 and transistor Q802. When the 'ignal is positive at the input side of R812, current flows into the summing junction of the amplifier which is the gate (Pin 3) of Q803 and this current causes the output of Q801 to go negative. This turns on the base emitter junction of Q802 and pulls current through diode CR801 so that the connection path is through R812, R807, CR801 and Q802 emitter to collector to -15 volt supply. The reason that Q802 is a transistor and not a diode is to equalize the output load on amplifier U801 in each of its two polarities, and avoid any parasitic oscillation which might occur in U801 because of unequal output current loading.

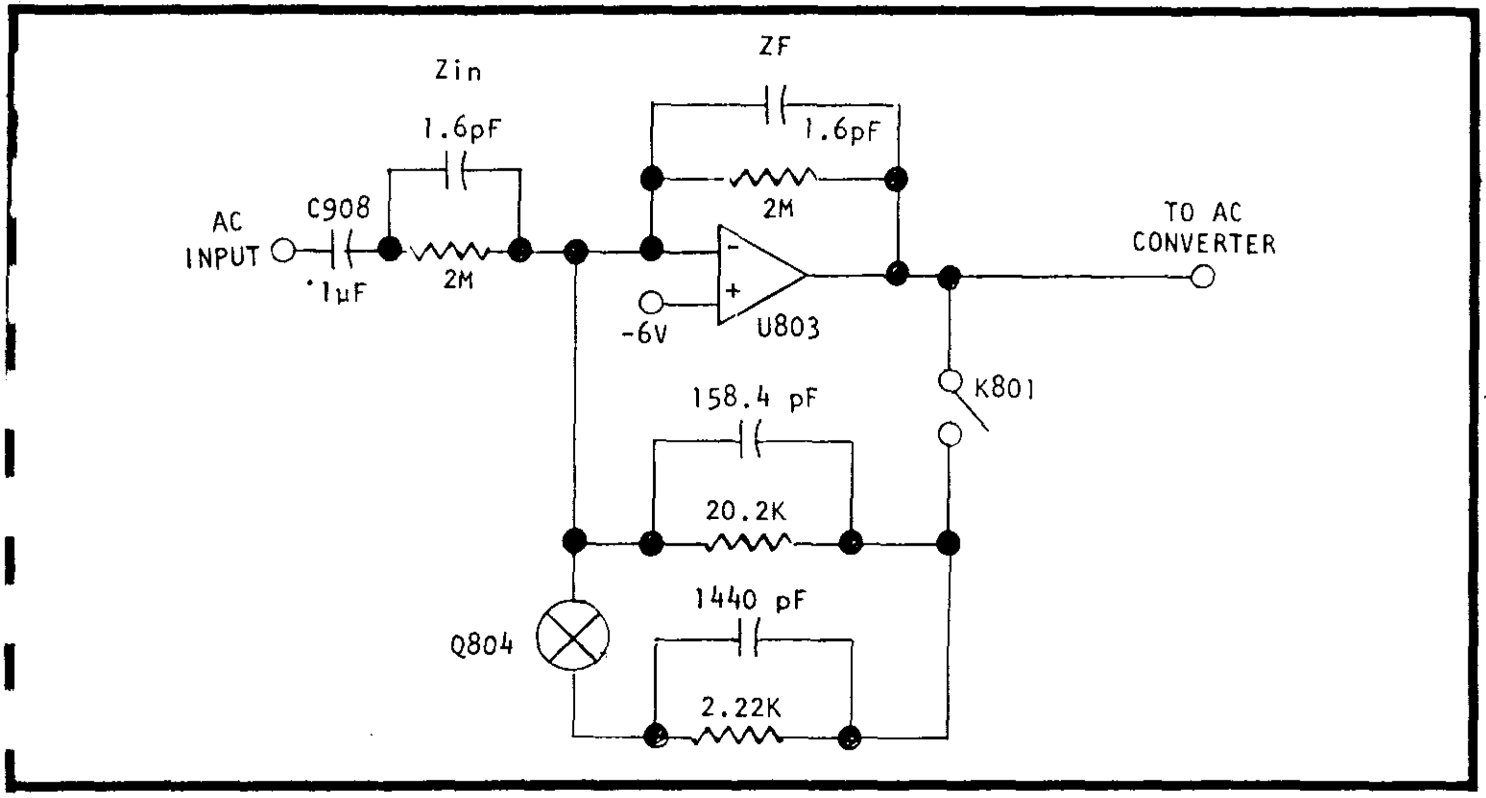


FIGURE 24. Simplified AC Attenuator Circuit.

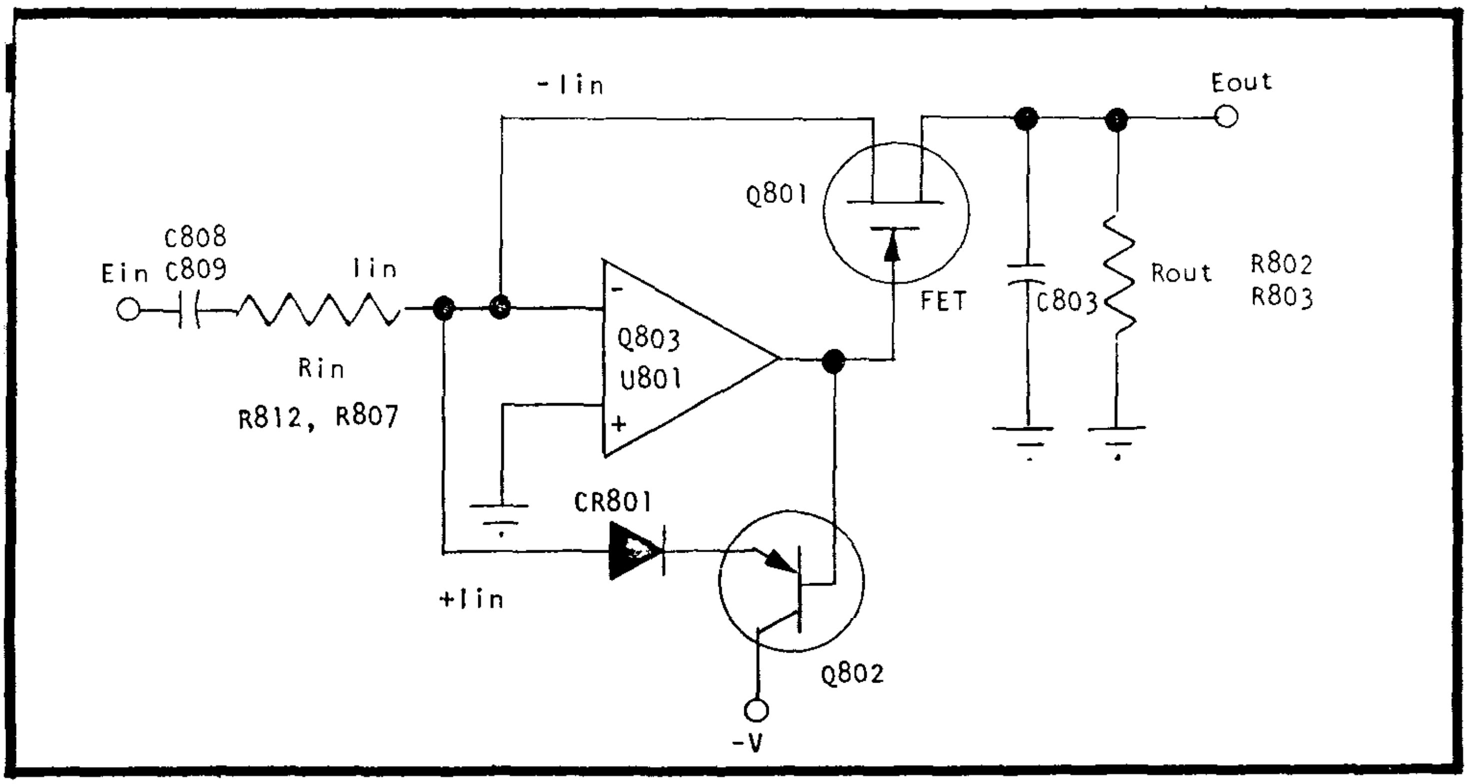


FIGURE 25. AC Converter Circuit.

4. When the input voltage is negative to the input side of R812 the current will flow out R807 and R812 and thus the output of Q801 will go positive, thus forward biasing the gate of Q801. This turns on Q801 pulling current through resistors R802 and R803 from signal ground. Thus Q801 only conducts for negative input signals and the output current is a half cycle sine wave of negative polarity. This output current flows thru C803 and R802 which filters the DC voltage. This filtering action allows the necessary 3 V DC with only 6 volts available from Q801. Without C803, more than 9 V swing would be needed. The transfer gain of the AC converter is unity. One volt AC RMS sine in causes 1 Volt DC out.

5. Q803 is a dual FET used as source followers with source resistors R805 and R806. The 10 m V adjustment feeds a small correction current to the summing junction to adjust for leakage current errors. The 1 Volt 1KHz adjust calibrates the system gain on the 300 m V and 3 V ranges. Additional output filtering is provided by the DC filter (Section 5 C) whose input is R801 & C801 in this case.

6. The only blocking capacitors needed are C808 and C809 on the input of the AC converter. They keep voltage offsets of U803 (AC attenuator) and Q803 and U801 from reaching the output.

7. The AC System common is the -6 Volt reference. It is composed of voltage follower U802 and input divider R811 and R810. C807 is used to provide a low impedance AC path between 6V and signal lo to minimize AC noise pickup.

f. Ohms Circuit.

1. The ohms circuit is a current generator. A summing amplifier configuration is used. The current is generated by applying a reference voltage to the input resistor of the summing amplifier and connecting the unknown resistor in the feedback loop of U702 to force the current through the unknown resistor. Refer to Figure 34a. Either the 3.3444 V or the .33444 V reference is connected to buffer amplifier U701 thru, switching FETs Q702 or Q703. The output of the buffer drives one of three resistors (3.3444K, 334.44K, 33.444MΩ) to give six decade values of current from 10 nanoamperes to 1 milliampere, and thus six ohms ranges. Each resistor consists of an adjustment potentiometer, a fixed resistor and the on resistance of a FET (no FET for 33.444MΩ).

2. High ohms puts the A/D converter on the 3 Volt range, allowing 6 resistance ranges which can turn on semiconductor junctions for on scale readings.

3. Low ohms puts the A/D converter on the 300 m V range, allowing 6 resistance ranges which do not turn on semiconductor junctions for on scale readings. See Table 5-3.

4. There are time and temperature drifts associated with amplifiers U701 and U702. These effects are compensated for by the A/D converter. The reference used to calibrate the A/D converter in Ω function is the output of U701. Therefore, any drift in U701 is compensated for every conversion cycle. The negative input of U702 is what "auto" zero" one is calibrated to every conversion cycle. Therefore, the stability of the ohms current is a function of only the stability of the Ω resistor. The lead drop in the high terminal of the ohms source amplifier is compensated for by connecting it to "auto-zero" 2 when in the ohms mode. "Auto-zero" 2 is the zero for the input signal. In 2-wire ohms the leads connect at the front panel binding post. Therefore a 4-terminal ohms system exists up to the front panel terminals. See Section 5-9.

5. The ohms switching FETs (Q703, Q702) are driven by transistor Q701 and the C-line, Q710 is driven from the A-line and Q707 is driven from the B-line. These lines are also used and decodes to operate the Model 173 autoranging current. Amplifier U702 is a FET input amplifier. This amplifier is overload protected by Q709 base emitter junction connected to the signal ground, and Q708 base emitter junction connected through Q706 clamp transistor. Thus the input swing is clamped. Very large voltage excursions on the output side of U702 are allowed. This is done by Q704, Q705, and CR703. Under normal operating conditions Q704 is operated in the saturated mode. However, under overload conditions, Q704 becomes a current source with its collector to emitter breakdown handling large voltage excursions when signals are positive with respect to the ohms source high. However, if signals are negative with respect to the ohms source high, CR703 reverse biases, cutting off that portion of the circuit. All of these high voltages will cause current to flow through R703 (120KΩ) which is connected to the +15 volt supply. The maximum limitation of 250 volts rms is a function of the power rating of R703 (a half watt resistor), and Q704's 400 volt breakdown.

TABLE 5-3.
OHMS RANGES

RANGE HIΩ	RANGE LOΩ	RANGE R	REF V_1	OHMS CURRENT	RANGE LINES A	RANGE LINES B	RANGE LINES C
3K	300Ω	3.3444K	3.3444V	1 mA	+8 V	-12 V	+8 V
30K	3K	3.3444K	.33444V	100μA	+8 V	-12 V	-12 V
300K	30K	334.44K	3.3444V	10μA	-12 V	+8 V	+8 V
3M	300K	334.44K	.33444V	1μA	-12 V	+8 V	-12 V
30M	3M	33.444M	3.3444V	100 nA	-12 V	-12 V	+8 V
300M	30M	33.444M	.33444V	10 nA	-12 V	-12 V	-12 V

g. Range Selection.

Ranging is accomplished by RSA & RSB lines going to LSI circuit U103. They are controlled by the front panel switches AUTO/MAN, DN & UP, according to Table 5-4. RSA & RSB are edge sensitive, causing range changes when their levels are changed. This causes one uprange or one downrange per button push.

TABLE 5-4.
Range Selection

Range Switches AUTO/MAN	Range Switches DN	Range Switches UP	Range Lines RSA	Range Lines RSB	Action
OUT	X	X	0V	+8V	AUTORANGE
IN	OUT	OUT	0V	0V	HOLDRANGE
IN	IN	OUT	+8V	0V	DOWNRANGE
IN	OUT	IN	+8V	+8V	UPRANGE
X = DON'T CARE					

h. Function Switching.

TABLE 5-5.
Function Selection

	FUNCTION SWITCHES					FUNCTION LINES		
FUNCTION	DC	AC	V/A	Ω	HI/LO	Ω	AC/DC	VI
DCV	IN	OUT	OUT	OUT	X	+8V	+8V	+8V
DCI	IN	OUT	IN	OUT	X	+8V	+8V	+8V (172) 0V (173)
ACV	OUT	IN	OUT	OUT	X	+8V	0V	+8V
ACI	OUT	IN	IN	OUT	X	+8V	0V	+8V (172) 0V (173)
HIΩ	OUT	OUT	X	IN	OUT	0V	0V	+8V
LOΩ	OUT	OUT	X	IN	IN	0V	+8V	+8V

X ≡ DON'T CARE

Function selection is accomplished by connecting function lines Ω, AC/DC, & VI according to Table 5-5. The function lines are level sensitive.

5-3. POWER SUPPLY, SCHEMATIC 28656E. This schematic contains the voltage regulators, line transformer, line voltage switching and power switching for the Models 172/173. There are three separate regulators used in the Model 172/173. One is a ±15 volt regulator, VR603, which has three percent accuracy, typically 0.1% regulation, and delivers ±15 volts at approximately a 65 milliampere level to most of the circuitry on the 172/173. There is also an 8 volt regulator, VR601, which is used as the positive supply to the LSI chip, (U103 on A/D converter schematic 27904F). There is also a +5 volt regulator, VR602. This regulator is used to drive the display, the digital logic circuitry in the A/D converter, and all the relays. VR603 is a ±15 volt dual tracking regulator. It is an integrated circuit with complete regulated circuitry and reference elements built into the unit. It is either driven by T601 transformer, or from ±19.2 volt batteries in the Model 1728 Battery pack. Connected to the transformer is a full wave rectifier, CR602, then two filter capacitors, C607 and C611, supply + and - 30 volts unregulated to VR603. These voltages are higher than VR603 needs because they are used to recharge the battery pack. If the instrument is off but the line cord is powered, unregulated voltages are generated.

If a Model 1728 battery pack is installed in the Model 172/173 the batteries of the Model 1728 will be charged through the unregulated voltages. When instrument is line powered, resistors, R604, R610, and R605, feed the charge inputs on the battery pack. These resistors drop the charging current down to the trickle charge level.

When the instrument is in the line operated mode, the +30 volts unregulated is connected to R601, which goes to the + input of VR603. The -30 volts unregulated, passes through R602 and goes to the - input on VR603. These resistors are used to absorb some of the excess power, which is not necessary to be dissipated in the regulator.

The 8 volt regulator, VR601, gets its unregulated input from the unregulated V+ input on VR603. This input goes through a dropping resistor, R606, to further reduce the voltage down to an acceptable level for VR601. The input for VR602 (5V regulator) is derived from transformer secondary 7 and 8, full wave rectifier CR601 and R603. This voltage also changes the 8.4V batteries. In BAT mode, the ±19.2 volt batteries and the +8.4 volt batteries connect to the input terminals of VR603 and VR602. VR601, the 8 volt regulator, is fed through the 270 ohm resistor. The line switch applies ac voltage from the transformer to the Model 1722 for its regulated 5 volt supply. Thus, when the 172 or 173 are turned off the 1722 turns off.

Transformer T601 has two internal shields, one secondary shield tied to pin 10, and one primary shield tied to power ground. This shielding provides line isolation. When the dual primary of T601 are tied in parallel by switch S601, the Model 172/173 is connected for 117 volt operation. Switch S601 also puts these primaries in series, for 230 volt operation, as indicated on the schematic. Provision for 100 volt line is interchanging connections 5 and 6 and connections 2 and 3 on the primaries. This is a physical wire change that must be made on the printed circuit board, and is a factory option.

There are two connectors for the Model 1728 battery pack, P602 and P606. The self-check terminals are on the rear panel. There is an "ac" self-check, "dc" self-check, and an "ohms" self-check. Connect from the appropriate self-check terminal to the input high terminal to exercise the instrument. The self-check is not accurate, the voltages and currents are only approximate. A battery test point on the bottom of the instrument allows checking of the +19.2 volt battery in the Model 1728. Normally the low battery light will indicate when the batteries have become low and need recharging. However, it could be used to troubleshoot for a defective cell.

5-4. DISPLAY BOARD, SCHEMATIC 27404D.

a. This schematic shows the display digits, the LED function indicators, all display drivers and timing mux generator. The entire display, including minus sign and function indicators are fully multiplexed. This is accomplished with six time slots (timing mux). The mux times are generated by shift register U301 whose inputs come from the LSI chip (U103, Schematic 27904F). These time slots are referred to as t_0, t_1, t_2, t_3, t_4, t_5. The common anodes of each digit and the common anodes of the function indicators are driven from the appropriate mux line, See figure 26. These mux times are also used in operating digital interfaces (See Section 5-8, 1722). The mux times occur in the sequence t_0 thru t_5, t_0 and t_1 are 383 microseconds each, and t_2 thru t_5 are 191 microseconds each. One complete mux cycle is 1.53 milliseconds.

b. The data mux lines, a, b, c, d, e, f, g, and dp drive the cathodes of the display segments and the function indicators. See Table 5-6. The data mux lines are generated in the LSI chip (U103, Schematic 27904F).

c. The 10,000 digit only indicates 1, 2, or 3 in overrange. If the 10,000 digit is zero, it is blanked by the data mux lines. It is necessary to operate the function indicator and minus sign twice as long as the digits. Since "AC" and "–" are activated during t1, the 10,000 digit time, t1 is as long as t0. To keep the 10,000 digit the same brightness as the other digits, a,b,c,d,e and f data mux lines for this digit are on for half of t1 time.

d. The anode driver transistors are saturating switches (Q301 thru Q306). The segment driver transistors are emitter followers (Q307 thru Q314). R302A thru R302H are current limiting resistors. Segment current is approximately 30 milliamperes peak. R303 & C301 decouple current spikes from the 5 volt power supply. C302 decouples U301 from power supply. CR301 and R304 prevent parasitic oscillation of segment driver transistors.

TABLE 5-6.
Display Data MUX Lines.

8 LINES	DRIVES DISPLAY SEGMENT OF INDICATOR LIGHT DURING					
	t_5	t_4	t_3	t_2	t_1	t_0
a	a	a	a	a	a for last ½ of t_1, Off other half	mV indicator-173 mV/mA indicator-172
b	b	b	b	b	b for last ½ of t_1, Off other half.	V indicator-173 V/A indicator-172
c	c	c	c	c	c Same as above.	μA indicator-173 not used-172
d	d	d	d	d	d Same as above.	mA indicator-173 not used-172
e	e	e	e	e	e Same as above.	A indicator-173 not used-172
f	f	f	f	f	AC indicator all of t_1	Ω indicator
g	g	g	g	g	g for last ½ of t_1 Off other half	kΩ indicator
dp	dp	dp	dp	dp	"-" indicator All of t_1	MΩ indicator

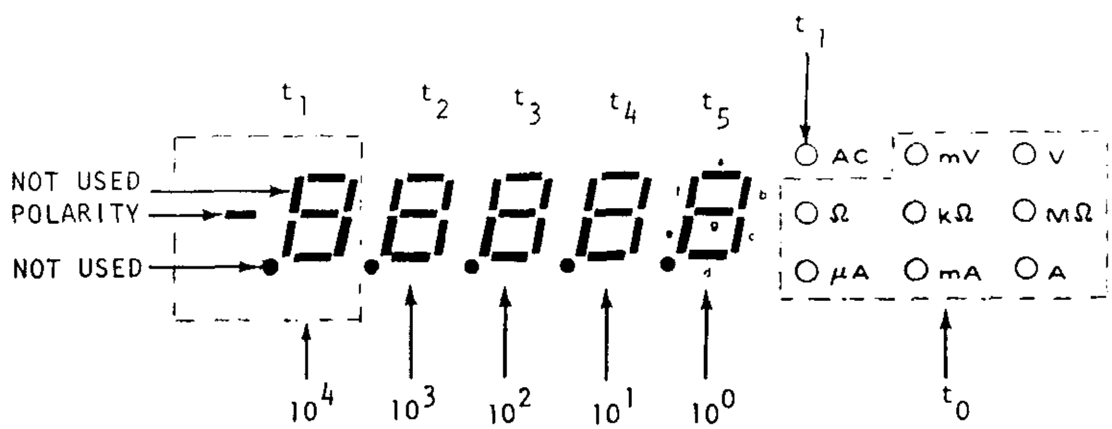


FIGURE 26. Digital Display Multiplex Scheme.

5-5. CURRENT BOARD. Schematic 27478D contains all of the current circuitry which is contained in the Model 173 and also in the 172. The current circuitry for the Model 172, shown at the bottom of the schematic consists of a 2 ampere fuse and a one ohm resistor. It is switched in front of the ac voltmeter or dc voltmeter for ac or dc amps. It allows 300 milliamperes on the 300 millivolt range, and up to 2 amperes on the 3 volt range. A limit of 2 amperes limits the power in the 1 ohm resistor. The input impedance is approximately 1.3 ohms on both the 300 milliampere and the 2 ampere range. Above 1 ampere the self-heating effect and TC of the resistor causes the reading error to increase.

For Model 173 the voltmeter is held on the 300 millivolt range and resistors are switched by means of relays K501, 502, 503, 504, or 505. K501 connects the input on the 300 microampere range, K502 on the 3 milliamp range, K503 on 30 milliamps, K504 on 300 milliamps, and K505 on the 3 ampere range. The current resistors are connected in series. R502 is connected to the high of the voltmeter (high sense). R510 goes to signal low (low sense). The measurement is thus done four terminal. The 3 ampere range is adjusted with potentiometer R512, the 300 milliampere range by R509, and the 30 milliampere range with R506. Input protection is provided by diode bridge CR501, which limits the voltage to 2 diode drops in either positive or negative polarity. Unity gain amplifier U501 guards the center connection of these diodes. This assures good performance on the 300 microampere range which nas 10 nanoampere sensitivity. A 3 amp medium acting fuse limits the maximum current. The fuse is rear panel accessible. The relay drive transistors are driven by U502. Spike suppression diodes across the relay coils prevent damage to the transistor drivers. Range lines from the LSI chip, lines A, B, and C autorange the ohms function, and the Model 173 current function. They are decoded in BCD to decimal decoder U502. See Table 5-7. There is a possibility of a small period of time during ranging where all relays may be open. This will not present an open circuit to the source because the diode bridge will conduct. Diodes CR507, 508, 509 block the signal lines, A, B, and C from reverse biasing the inputs of U502 when at -12V. Resistors 515, 516, 517, 513G, 513H and 513F are input dividers to drop +8 volts to 5 volts to protect U502. Resistors R513 D,C, A, B and E limit base current to the transistor drivers. Resistors for the top three current ranges are adjusted in shunt rather than in series. Although adjustment ranges are equal plus and minus from the nominal value, the adjustments are nonlinear. Resistors R511, R508, and R505 limit the range of the adjustment in one direction. The pots plus these resistors limit the adjustment range in the opposite direction. U501 has a maximum input current of 7 nanoamperes (less than 1 digit on the 300µA current range).

TABLE 5-7.
173 Current Ranging

RANGE ACA & DCA	RANGE RESISTANCE	RELAY OPERATED	RANGE LINE LEVELS A	B	C
300µA	1KΩ	K501	+8V	-12V	+8V
3mA	100Ω	K502	+8V	-12V	-12V
3 A	10Ω	K503	-12V	+8V	+8V
300mA	1Ω	K504	-12V	+8V	-12V
3 A	0.1Ω	K505	-12V	-12V	+8V

5-6. MODEL 1728 RECHARGEABLE BATTERY PACK. The Model 1728 provides ±19.2 volts and +8.4 volts from nickel-cadimum batteries. BT401 and BT402 are 19.2 volt, .45 AH nickel cadmimum packs which are fused by 1A, 3AG Slo-Blo fuses. BT403 is an 8.4V pack composed of seven 1.2 volt "C" cells and is also fused by a 1A, 3AG, Slo-Blo fuse. The Model 1728 has a built-in recharging circuit which operated from ±29.5V unregulated supplied by the DMM line-power supply.

a. BT401 Charging. BT401 is charged via a constant current from Q401. Diodes CR401 and CR402 and resistor R402 place a diode drop across R401. The resulting current is the maximum charging current. Diode CR403 prevents the battery from supplying current through Q401. The maximum charging current occurs only when the DMM is set to OFF. A trickle charge is maintained when the DMM is line operated. The reduced current is obtained by inserting a limiting resistor in series with the charging circuit (not shown on Schematic 26758C). In full charge, the batteries are charged at a C/10 rate (45 mA for BT401 & BT402, & 200mA for BT403). When trickle charged, the charge rate varies according to line voltage & battery condition from a minimum of C/100 rate to a maximum of C/20 rate. Thus, trickle charge may never fully charge the batteries, but is intended to put sufficient charge into them for short intermittent use.

b. BT402 & BT403 Charging. BT402 & BT403 are charged via a constant current from Q402 or Q401 respectively. These circuits operate similarly to the above circuit, except that they are powered by unregulated ±29.5V.

5-7. ANALOG-TO-DIGITAL CONVERTER. (Schematic 28656E).

a. Introduction.

1. The A/D converter, as its name implies, performs the function of generating a digital representation of an analog voltage applied to its input. The basic functional blocks involved in this process are shown in Figure 27. This A/D converter has several distinct modes of operation, broadly grouped as "signal-measurement mode" and "error-correction mode". The signal flow in the signal-measurement mode is shown in heavy lines in Figure 27. It can be seen that the transformation from voltage input to display output occurs in two major blocks. The first block (V/F Converter) generates a digital pulse train whose frequency is proportional to the input voltage. The second block (digital chip) contains circuitry which counts the incoming pulses for a fixed time period, producing a total count which is proportional to the average of the input voltage over that time period.

2. The digital chip (a custom MOS LSI circuit) which performs the pulse counting function also performs a number of other functions necessary for the analog-to-digital converter, and for other portions of the DMM. Details of the operation of this digital subsystem will not be given in the following discussion. However, various of its outputs which are necessary for the operation of the remainder of the A/D converter will be referred to when necessary.

3. The first step of the A/D conversion process, the Voltage-to-Frequency conversion, is performed using a principal known as charge balancing. The resulting output pulse train has the property that its average frequency over a given time period is proportional to the average of the input voltage over the same time period. Thus, the charge balance technique has the property that the digital output is a representation of the true integral of the analog input over any specified sampling time. The circuitry which performs the V/F function is explained in detail in Section b.

4. The charge-balance circuitry described in Section b, although highly linear, has certain intrinsic scale factor and zero offset errors. In the complete A/D converter these errors are corrected for by the use of additional circuitry. This so-called Auto-Zero and Auto-Calibrate circuitry is described in Section c. Section d contains a description of overall A/D converter system operation, combining the circuit functions described in sections b and c into a complete A/D conversion cycle.

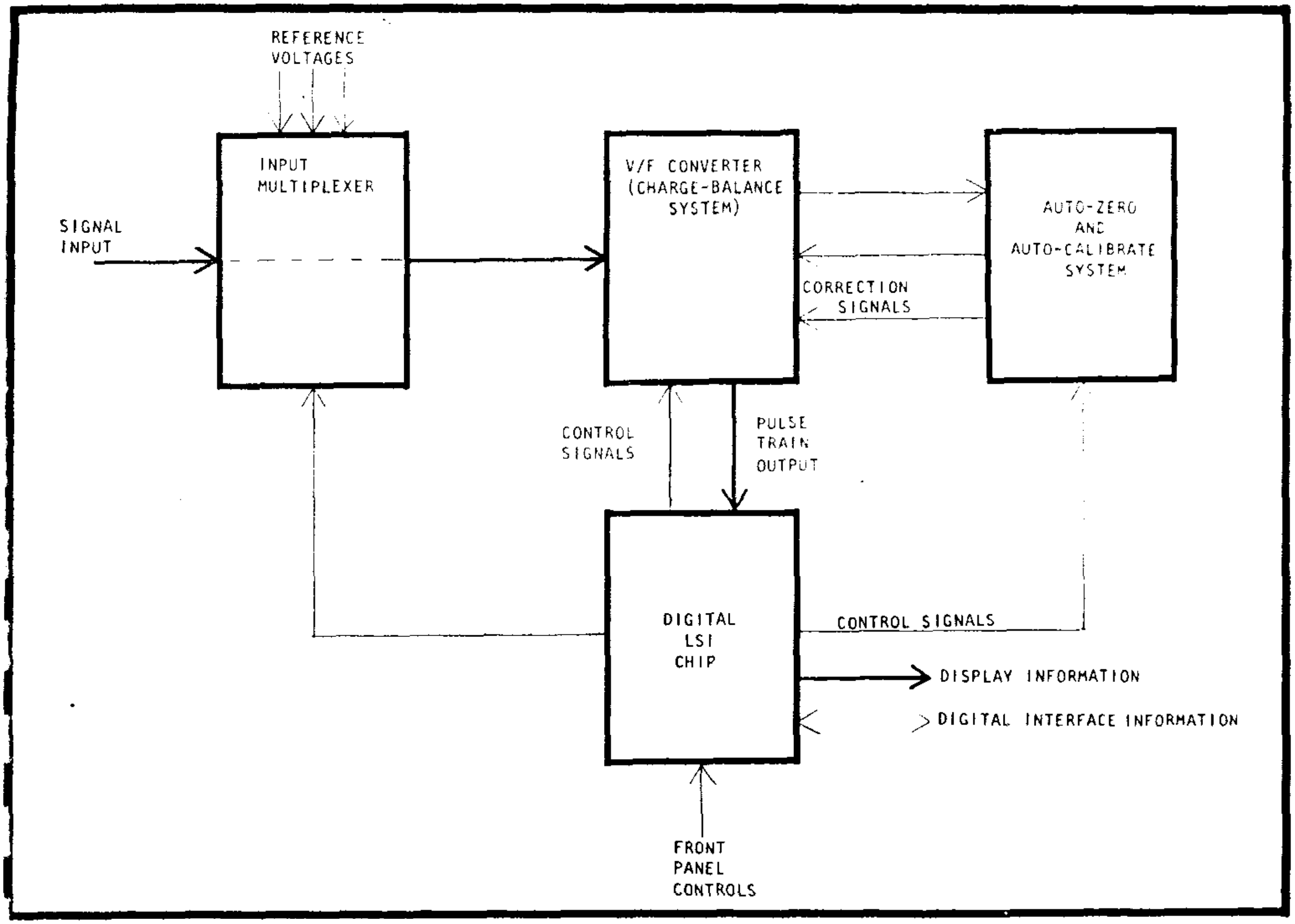


FIGURE 27. Basic Functional Blocks of A/D Converter.

b. Voltage-to-Frequency Converter.

1. The greatly simplified circuit shown in Figure 28 illustrates the basic principles of the charge-balance V/F converter. Its operating waveforms are shown in Figure 29. Assume the integrating capacitor voltage, V_i, to be initally negative. As the input signal current I_x is integrated by the capacitor, V_i rises and eventually becomes more positive than the threshhold of the comparator (time t_1 in Figure 29.). The comparator output voltage V_c, which is a logical variable, then rises to a logic 'one'. At the next positive-going edge of the clock C1D (time t_2 in Figure 29), this 'one' is latched by the flip flop and appears as the latched output QR. A quarter of a clock period after that event, (at t_3), the out-of-phase clock, C1, goes high and enables the output of the AND gate,thereby turning on the current switch. For the next half clock period, from t_3 to t_5, the reference current I_r is forced to flow out of the integrating capacitor, discharging it and bringing V_i to a negative value. Sometime (t_4) during this reference current pulse, V_i crosses the comparator threshhold in a negative direction and V_c goes to a logical 'zero'. At the next positive-going edge of clock C1D, (t_6), the comparator voltage V_c, is still a zero and therefore the flip flop output also becomes a zero. The reference current consequently is not turned on during that clock period, and in fact stays off until the next time the integrator voltage once again rises above the comparator threshhold.

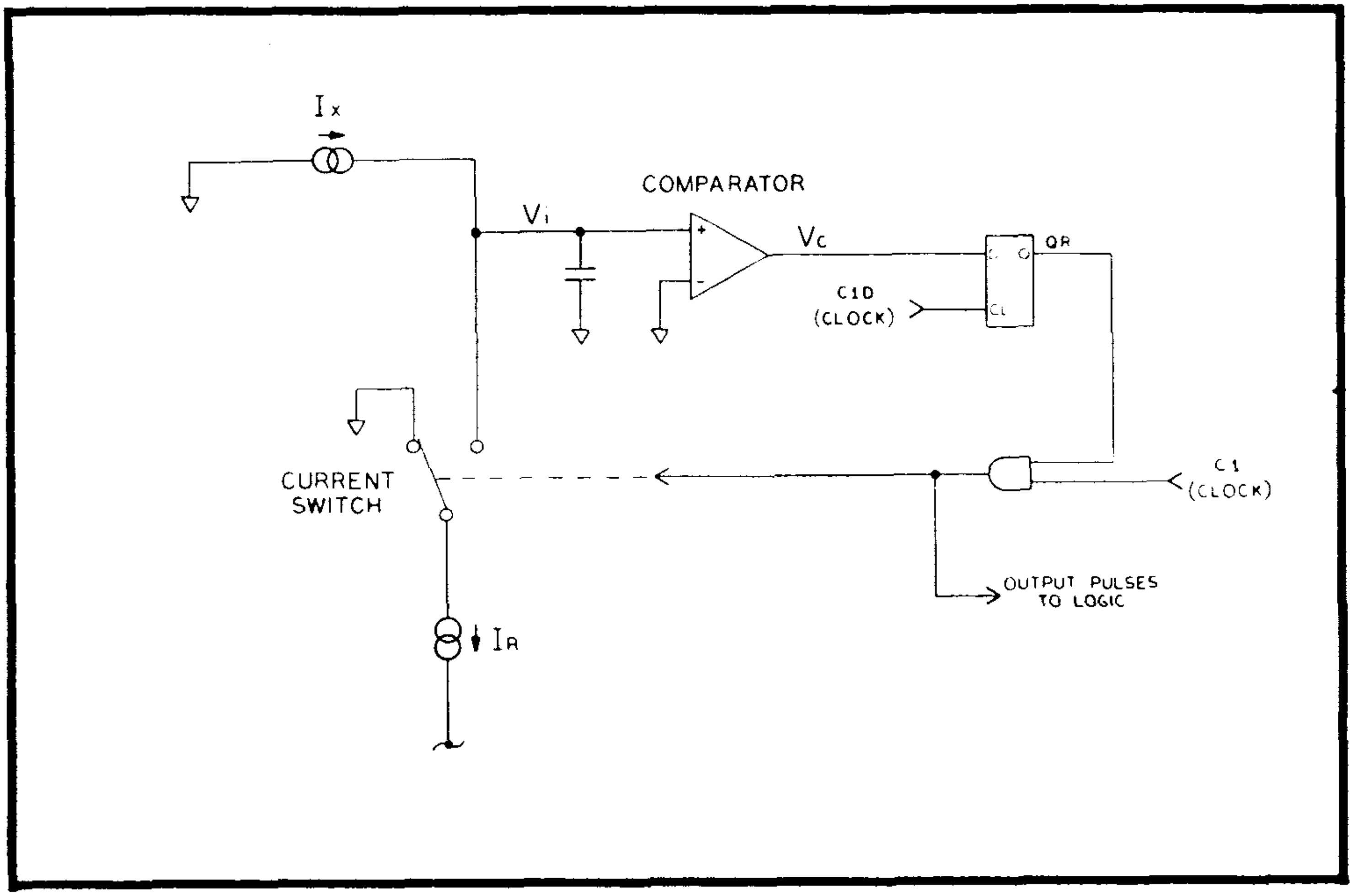


FIGURE 28. Basic Charge-Balance Converter.

2. For relatively large values of the input, the time required for the integrating capacitor to be recharged above the comparator threshhold is relatively small, and the charging-discharging cycle described will occur at a high frequency. For lower values of input current, the recharging time of the integrator will be correspondingly longer and the events described will occur at a lower rate. Thus the repetition rate of reference current pulses (and digital output pulses) is a function of the input current.

3. Notice that the amount of charge removed from the integrating capacitor during each discharge cycle is equal to the product of the reference current, I_r, and one-half the clock period. Through appropriate circuit design these two parameters can be made very stable, with the result that, whether the frequency of the discharge cycle is high or low, each increment of charge removed (i.e., each reference current pulse) is precisely the same size. Since the total charge removed from the capacitor in any given time period is equal to the total charge that flowed in during the same time period (within a resolution of one discharge increment) the uniformity of size of the reference current pulse guarantees that the total number of such pulses is precisely proportional to the time-integral of the input current.

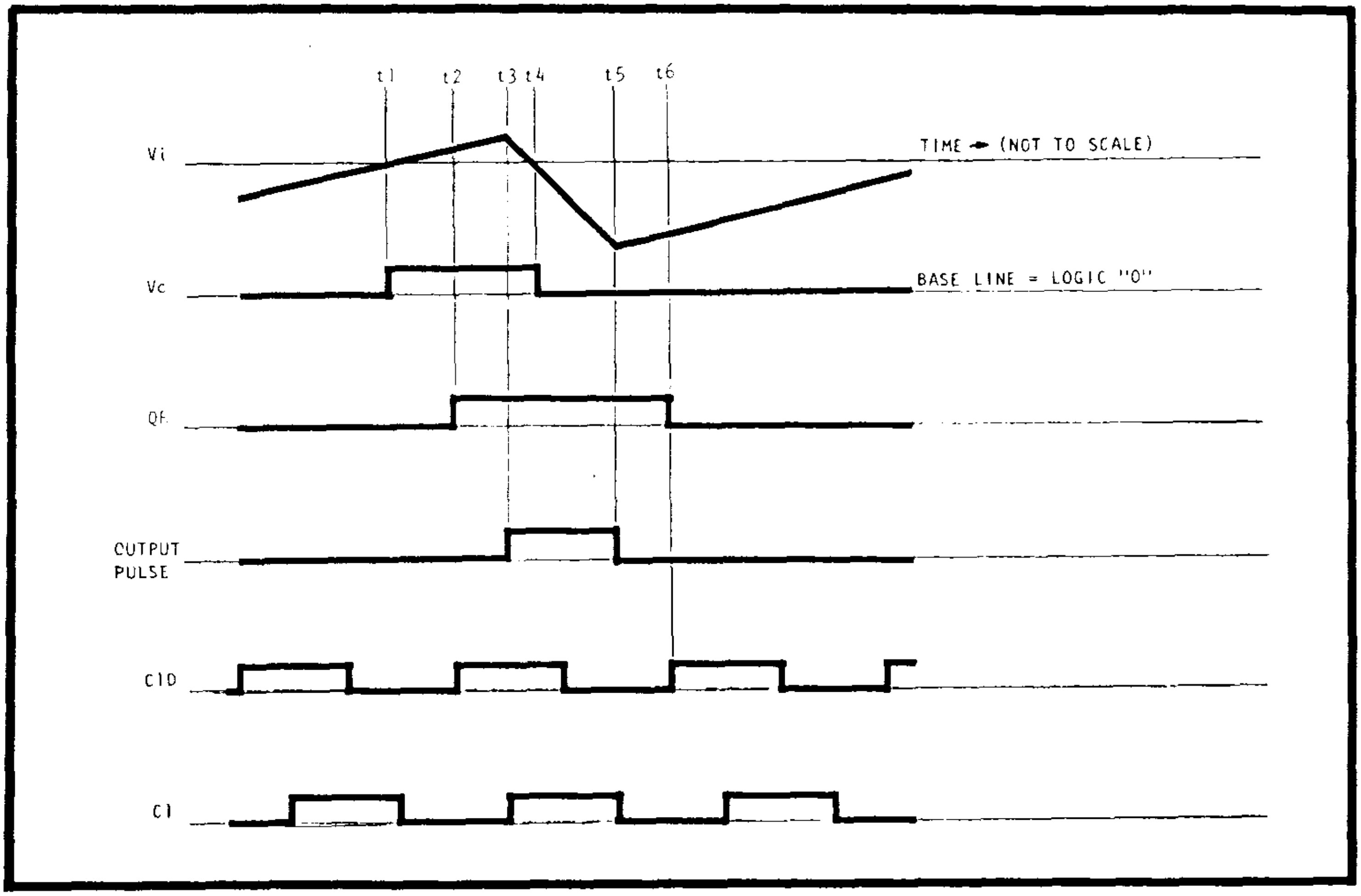


FIGURE 29. Operating Waveforms of A/D Converter.

4. Figure 30 is a simplified schematic diagram of the circuitry actually employed to perform the V/F conversion. In addition to some added details of the circuitry already discussed, Figure 30 shows three major circuit elements not previously mentioned.

a) The input buffer amplifier, U202, serves two functions. First it provides a high impedance input to the A/D converter. Second, it provides a selectable voltage gain of 10, giving the A/D converter in effect two voltage ranges, selected by the line labeled G10 (an output from the LSI chip).

b) The transconductance amplifier, consisting of op amp U101 and its associated MOS FET (Q104) and resistors, converts the voltage which appears at the output of buffer amplifier U202 into a proportional current, I_x, which is used to charge the integrating capacitor.

c) The reference diode and the resistor connected from it to the summing junction of op amp U101 provide a fixed current component of I_x, in addition to the variable component I_s (which is proportional to the input voltage). This fixed offset current, labeled I_o, allows the overall A/D converter to handle both positive and negative input voltages. With this arrangement, the output pulse frequency is one half of its maximum possible value when the input voltage to the entire converter is zero. This transposition is accounted for in the digital subsystem (LSI chip) by subtracting a fixed number from the accumulated count before displaying it.

d) The remaining circuitry in Figure 30 is functionally equivalent (with some added details) to the basic charge-balance loop shown in Figure 28. The digital output signals QR and CLK are used by the digital subsystem, in effect, to reconstitute the pulse train discussed in connection with Figure 28.

c. Auto-Zero and Auto-Calibrate Circuitry.

1. The charge balance system shown in Figure 30. is inherently highly linear, but both its zero and full-scale calibration (scale factor) are susceptible to drift with time and temperature, due to a variety of effects. Through the use of a pair of related circuit functions, referred to as Auto-Zero and Auto-Calibrate, these intrinsic errors can be cancelled, resulting in a system whose scale factor is essentially as stable as the voltage of a reference zener diode and whose zero stability is limited principally by thermo-electric offsets. The techniques used to achieve this performance are described in this section.

2. It can be shown that all zero-error sources in the charge balance system (such as offset voltage drift of amplifiers U202 and U101, input current drift of amplifier U101, etc.) can be represented as a total effective error current at the summing junction of amplifier U101. In a similar way, all gain errors are equivalent to an error current at the emitter of the reference current output transistor, Q102B. It is thus possible to correct for all such errors by introducing an appropriate correction current at each of these two locations in the circuit. The function of the Auto-Cal and Auto-Zero circuitry, then, is to discover the proper values of these two currents and to supply them during the measurement of the input signal.

3. The method used to "discover" the proper value of the correction signals is as follows: Consider first the Auto-Zero operation. In an error-free system, a zero-volt input would cause the charge-balance loop to deliver reference-current pulses to the integrator at exactly 1/2 the clock frequency. In the Auto-Zero mode, the buffer input is supplied with zero volts, and the current switch is digitally forced to deliver reference-current pulses at precisely 1/2 the clock frequency. In a real system with finite offset errors, the current being delivered to the integrat-

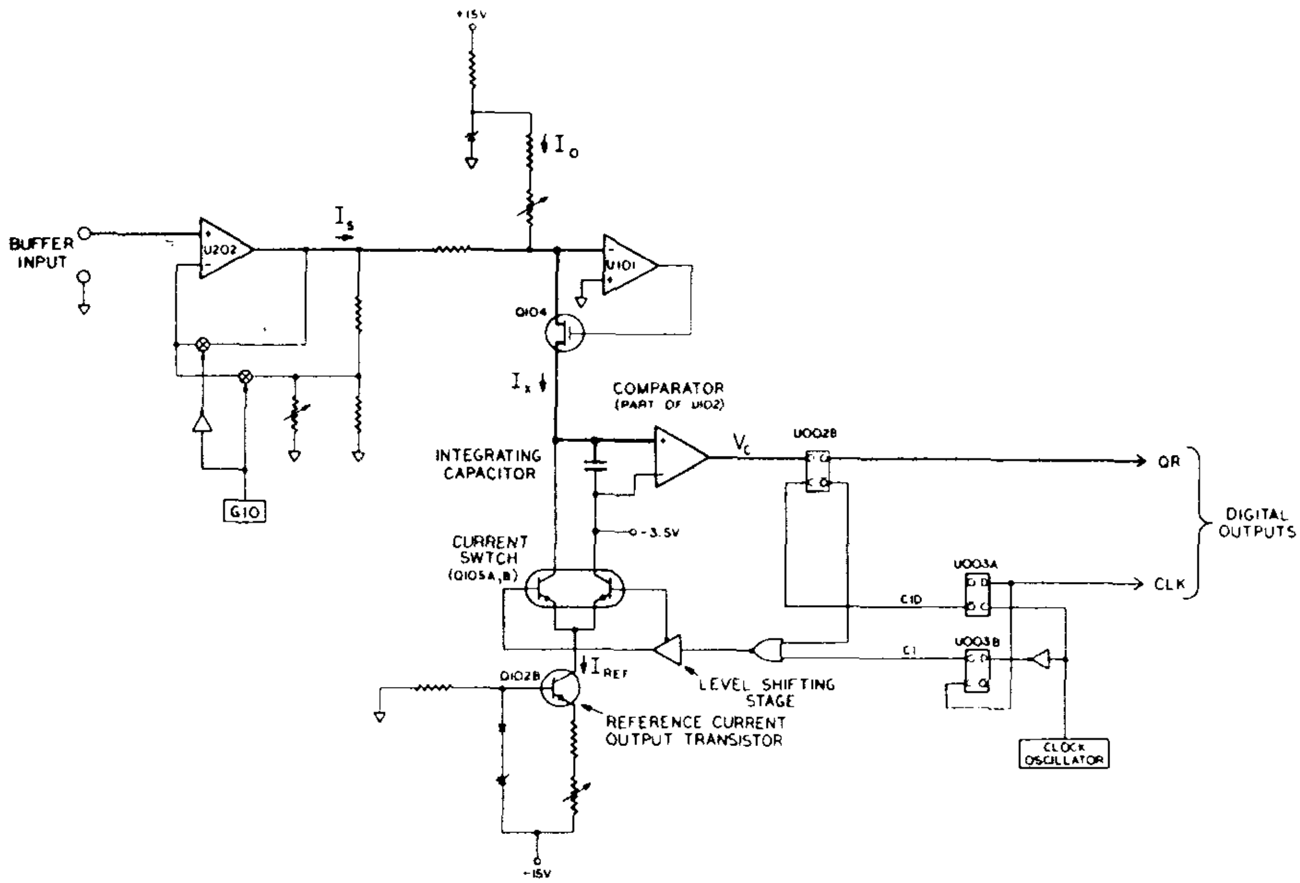


FIGURE 30. Simplified Schematic of V/F Converter.

or through the transconductance amplifier (I_x) does not exactly match this forced reference current; the difference exactly equals the correction current required to cancel the offset errors. Thus the integrator voltage, V_i, exhibits a charge balance sawtooth waveform like that shown in Figure 29., superimposed on a much slower ramp whose slope is proportional to this difference current. The auto-zero feedback system adjusts a correction current which flows into the summing junction of amplifier U101 so that the slope of the ramp is equal to zero. In this way, all zero errors are precisely cancelled.

4. The Auto-Calibrate system works in an analogous manner, with three differences of detail:

a) The voltage supplied to the input of buffer amplifier U202 is the exact amount voltage which the charge balance system can measure.

b) The current switch is forced to a frequency equal to the clock frequency rather than one half of it.

c) The feedback correction current is delivered to the emitter of the reference current output transistor (Q102B).

5. The circuitry which performs the operations described above is shown in Figure 31, together with most of the charge balance system redrawn from Figure 30. The added circuitry is grouped in five major blocks:

a) Input Multiplexer,

b) Reference current forcing circuitry,

c) Comparator filter,

d) Auto-Zero feedback and storage circuitry,

e) Auto-Cal feedback and storage circuitry.

6. This circuitry will be described block by block with reference to the above description of its basic mode of operation.

a) The input multiplexer supplies the necessary "known" voltages to the input of the buffer amplifier at appropriate times, and connects the buffer amplifier to the signal source when that signal is to be measured. The multiplexer consists of JFET switches controlled by signals from the LSI chip. (the two adjustable capacitors shown in Figure 31. are used primarily to neutralize the JFET switching charge in order to minimize the A/D input current.)

b) The reference current forcing circuitry controls the input of the comparator latch flip flop. In the Auto-Zero mode, it forces the output of this flip flop to alternate between one and zero on successive clock periods. The resulting reference current pulse rate is equivalent to an output frequency from the charge balance system of 1/2 the clock frequency. In the Auto-Calibrate mode QR is forced to a one constantly with the result that the reference current is on at every opportunity; reference-current pulse frequency thus equals the clock frequency. Two chip outputs, FON and COFF, are used to control these two operating modes: FON is one during both Auto-Zero and Auto-Calibrate, and COFF is zero during Auto-Zero and one otherwise.

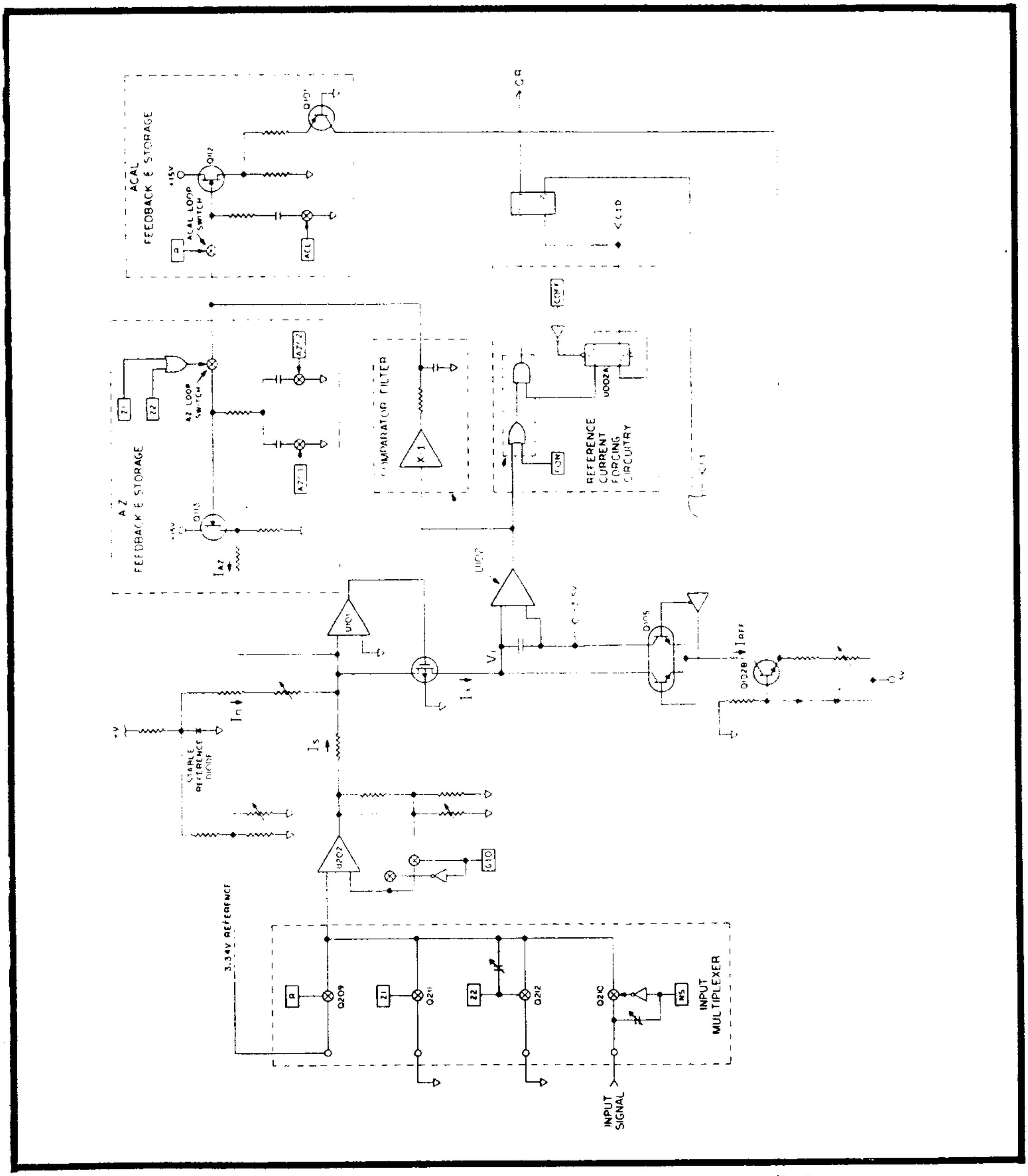


FIGURE 31. Simplified Schematic of Complete A/D Converter.

c) The block labeled "Comparator Filter", not previously mentioned, serves an important function in the Auto-Zero and Auto-Calibrate feedback loops. As discussed above, the component of the integrator voltage which is of interest for Auto-Zero and Auto-Cal purposes is the slow ramp arising from the effective error currents. Because this ramp has superimposed on it a relatively high frequency triangle waveform, the combination of comparator and comparator-filter functions as a switching-mode (class D) amplifier for the ramp voltage, with gain equal to the ratio of the V_c switch to the triangle amplitude. The comparator-filter's function is to smooth the switching output of the comparator so that only the low-frequency amplified ramp signal is passed on to the remainder of the Auto-Zero (or Acal) feedback loop.

d) The Auto-Zero feedback and storage block completes the control loop used to generate the Auto-Zero correction current. Ignore for the moment the two storage capacitors and consider only the direct signal path via the Auto-Zero loop switch and the JFET source follower. Consider the following circuit elements: Transconductance amplifier, integrating capacitor, switching mode amplifier (comparator and comparator filter), auto-zero loop switch, source follower and the resistor between FET source and U101 summing junction. Examination shows that these circuit elements constitute a simple low-frequency and dc feedback loop which will strive to adjust the voltage across the integrating capacitor to a value near zero. Once this condition has been achieved, then the Auto-Zero correction current I_{AZ} must have taken on the desired value, since the total current being fed to the integrating capacitor must now be exactly balanced by the switched reference current.

The remainder of the auto-zero system operation is quite simple. Once the stable closed loop condition has been achieved, one of the two capacitor switches is then closed and the gate voltage on the source follower (which has the value necessary to produce the correct value of I_{AZ}) is stored on that capacitor. When the loop switch finally opens at the end of the Auto-Zero phase, the value of I_{AZ} which was established during the Auto-Zero phase thus remains in effect until the next Auto-Zero operation.

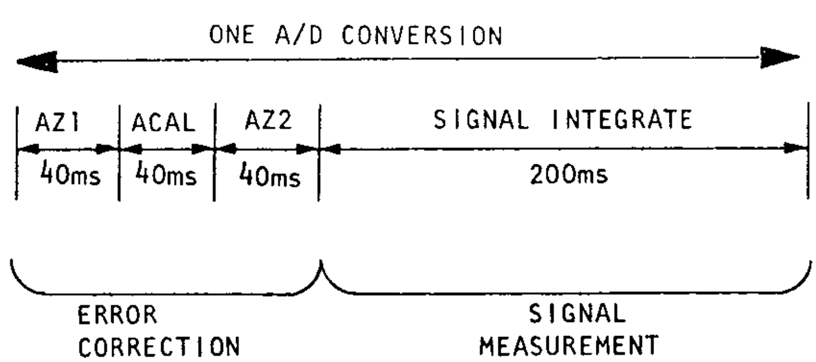


FIGURE 32. A/D Converter System Timing.

e) The Auto-Cal feedback and storage block works in a manner identical to that of the Auto-Zero feedback and storage block, with the exception that its output current is fed to the emitter of Q102B instead of the summing junction of U101. Although the Auto-Zero and Auto-Cal correction operations interact to some degree, a few sequential iterations of these operations suffice to establish the correct values of the two correction currents.

d. Overall A/D System Operation.

1. In the preceeding two sections the structure and function of each major analog circuit block has been explained. This section contains a description of the manner in which these elements are combined in a complete A/D conversion. The description is based on Figure 32, an overall A/D converter timing diagram showing one complete conversion.

2. The first major division of the conversion period is into an error-correction segment (120 ms long) and a signal-measurement segment (200 ms long). During the former, the input multiplexer supplies known reference voltages to the V/F block, and (as described in Section c) the correction currents I_{AZ} and I_{ACAL} are established. During the latter, the now error-corrected V/F converter has the unknown signal voltage applied to its input, and its output pulses are counted by the digital chip. (As the next conversion period begins, the chip processes the resulting pulse-count and displays the result.)

3. The error-correction segment of the conversion cycle is further divided into three 40-msec. phases. During the first two of these phases, the buffer amplifier gain is held constant at either 1X or 10X (depending on DMM range and function). During the AZ1 phase, the input multiplexer supplies the buffer with a zero-reference voltage, and the Auto-Zero feedback loop is closed. The value of I_{AZ} required to correct any system zero-errors is established, and the closure of the AZC1 switch (see Figure 31) causes the source-follower gate voltage which produces this current to be stored on the corresponding Auto-Zero storage capacitor.

4. During the ACAL phase, the multiplexer connects the buffer input to a full-scale reference voltage (either 3.34 or 0.334 V, depending on buffer gain), and a similar process results in a scale-factor correction voltage being stored in the Auto-Cal storage capacitor.

5. Buffer gain during the AZ2 phase is always the same as it is during the signal-measurement phase; it may differ from its value during AZ1 and ACAL. Because of the (possibly) changed buffer gain, the effective system offsets may have changed so the second Auto-Zero operation is required to prepare the V/F converter for an error-corrected signal measurement. This new value of the Auto-Zero correction voltage is stored on the capacitor controlled by the AZC2 switch (Figure 31.).

5-8. MODEL 1722 DIGITAL INTERFACE.

a. Overall Block Diagram. As shown in Figure 33, Serial data from the DMM and its associated clock lines are first isolated. Bidirectional data line SERDAT is then split. Output data DOWNDAT goes to the output register block where it is converted to parallel form and then to the output buffers. The clock lines go to the control block which decides where the data is going, out or in, and also generates the flag.

Control input data and strobes are first buffered by the input buffer block. The strobes go to the output buffer to gate the outputs. The control data inputs go to the input register and control block where they are converted from parallel to serial form and sent to the isolation block. The input register and control block also decides, based on control data input, whether there is to be an output update. Power isolation for the 1722 is provided by transformer T1001 which is powered by a secondary winding of the DMM power transformer.

b. Signal Isolation. The bidirectional data line SERDAT and the two clock lines SERCLK and INCLK each drive an emitter follower made up of transistors Q1036, Q1035, and Q1037 whose loads are LED's in the opto-isolators are pulled up by resistors R1010, R1009 and U1018, which is driven by Q1034 similar to the three just mentioned. The output pullup on U1018 is on the DMM mainframe. Power for the DMM side of the isolation is taken directly from the DMM +5 volts through R1016 and C1018 and C1017, which provide the coupling.

c. Power Supply. Low voltage ac from the secondary of the DMM transformer is supplied via pins B and C on J101A.

Switching for the power for T1001 provided at J1003 Pins A and B and comes via the DMM mainframe through its Power On switch. The secondary of T1001 is rectified, filtered and run through an integrated circuit +5V regulator TR1001, where it is again filtered by C1015, C1002, C1003, C1004, C1014. The core of T1001 is connected to chassis ground by a green wire to a screw on the DMM mainframe or transformer. Also common mode filtering is performed by R1008 and C1006 between output low and chassis ground.

d. Control Block. UPCLK, the isolated form of INCLK, is run to the trigger input of E1017 timer. A buffered version of UPCLK is also run via diode gate CR1002 to the threshhold input of U1017. U1017 is such that its output will go high when a falling edge goes into trigger. A filter made up of R1007 and C1008 will try to charge, however, since this threshhold is clamped low through diode CR1002. It will not be able to time out in the time period of the clock pulses on INCLK until the last rising edge of INCLK, at which time it will clock out at 30 microseconds, therefore UPTIME, the output of U1017, will be length of the INCLK pulse stream plus approximately 30 microseconds, which is the time in which data will be flowing from the 172 to the DMM. The beginning conversion (See Schematic 27902E). This is done by clocking DOWNCLK with UPTIME in flip-flop U1015A. The beginning of downtime also defines the time when the flag is set high, that is when data has finished being updated. Setting the flag low during data change time, or resetting the flag, is accomplished in two ways: FR or UPDATE. Downtime also gates DOWNCLK thru U1014C & U1014D where it is called GATECLK and goes to the output register.

e. Output Register. The output register is made up of shift registers U1008A & B, 1009A & B, 1010A & B, 1011 A & B. It is a 32-bit shift register, of which only 30 are used. Serial data enters U1008B and is clocked through all of the shift registers by the parallel clock, GATECLK. At the end of the clocking time all 30 bits have been shifted in and are presented in parallel to the output buffer.

f. Output Drive and Buffer. Parallel data on the output registers goes to output gates U1001 thru 1007 and U1012 and 1013. Here they are gated with the output strobes and drive transistors Q1001 thru 1030 to output connector R1006.

g. Input Buffers. Strobelines are buffered by U1101 and U1102 and go out to the output drive and buffer block. Remote control inputs are buffered by U1104, U1111, U1105. U1104 is a Schmitt trigger and is put on certain control lines to prevent false triggering.

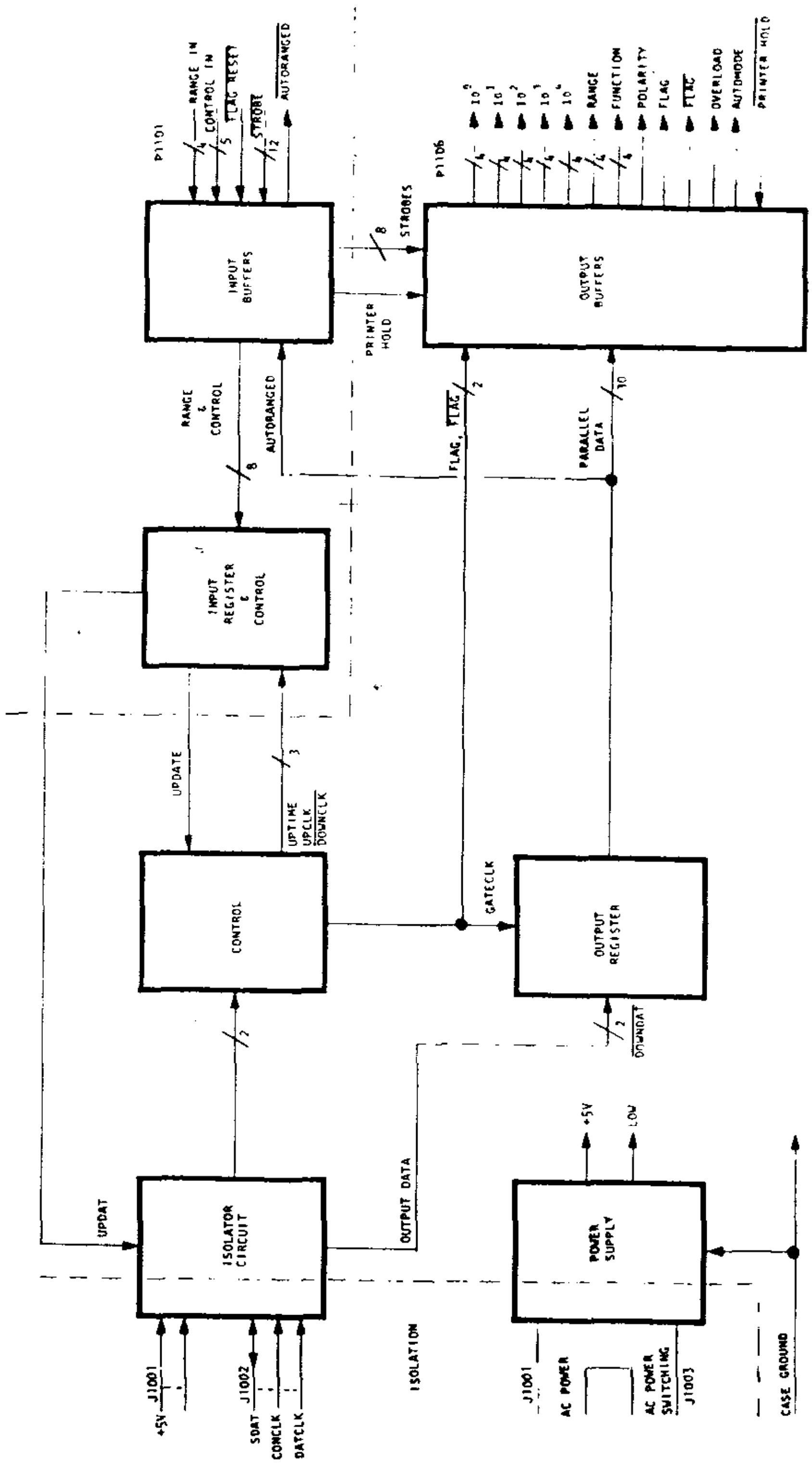


FIGURE 33. Model 1722 Block Diagram

5-9. DETAILED 4 WIRE OHMS OPERATION.

a. The circuit measures a resistor by putting a constant current through Rx and measuring the voltage drop across Rx. This is accomplished by putting Rx in the feedback of a summing amplifier (Ω AMP) the input to this amplifier being a reference (Ω Vref) voltage through an input resistor (RΩ).

b. AZ-1, ACAL, AZ-2, & A/D Signal are the 4 A/D inputs. This A/D operation compensates for time & temperature variation of Ω VRef and Ω Amp, as well as compensating for lead resistance. The A/D looks at each of these inputs in time sequence in the following manner.

1) AZ-1 looks at Ω AMP input for 40 ms and stores this zero level.

2) ACAL looks at Ω VREF for 40 ms and calibrates itself to the difference between AZ-1 and ACAL. Thus, it is calibrated to the voltage across RΩ . Since RΩ is a fixed stable resistor the value of I is now known. Since I flows through Rx the calibration is fixed.

3) AZ-2 looks at the voltage at the top of Rx for 40 ms. This is defined as the zero level for signal measurement and is stored in A/D.

4) A/D Signal looks at the bottom of Rx for 200 m seconds. The A/D thus measures the difference between A/D signal and AZ-2 without polarity sign. The voltage across Rx is displayed.

c. The measurement is essentially a ratio measurement between the voltage across Rx and the voltage across RΩ.

d. Note that the voltage at the top of Rx is essentially at signal LO of the instrument (± ΩAMP offset and lead resistance drop) and the voltage at the bottom of Rx is negative. Thus, the high impedance terminal is guarded and relative fast response is achieved at high resistance values.

SECTION 6. MAINTENANCE.

6-1. GENERAL. This section contains information necessary to maintain the instrument. Included are procedures for Electrical Performance Verification, Calibration, Trouble-shooting, and Battery Replacement and Charging.

6-2. REQUIRED TEST EQUIPMENT. Recommended test equipment for checking and maintaining the instrument is given in Table 6-1. Alternate test equipment may be substituted if specifications equal or exceed the stated characteristics.

TABLE 6-1.
List of Test Equipment For Performance Verification.

ITEM	DESCRIPTION	SPECIFICATION	MFR	MFR MODEL
A	DC Calibrator	±0.2 V through ±1000 Vdc ±0.002% or 20µV	FLUKE	343A
B	AC Calibrator	0.2 through 20 v rms ±0.022% + 10µV	HP	745A
C	High Voltage Amplifier	200V through 1000.0 v rms ±0.04%	HP	746A
D	Decade Resistor	2KΩ through 10MΩ ±0.01%	ESI	DB62
		200MΩ ±0.1%	CADDOCK	MG750
E	Current Source	200µA through 20 mA ± 0.006%	FLUKE	3330B
		200mA and 2A ±0.02%	FLUKE	382A
F	Ohmmeter	$10^7\Omega$ ±1% $10^9\Omega$ ±5%	KI	616

NOTE
The equipment listed here in many cases will introduce an additional uncertainty in the Performance Verification. The Absolute Accuracy should be used when evaluating the displayed reading on the DMM.

6-3. PERFORMANCE VERIFICATION. Use the following procedures to verify basic operation of the instrument. All measurements should be made at ambient temperature of 25°C. and relative humidity less than 80%. If the instrument is out of specification at any point, perform a complete calibration as given in paragraph 6-4. For each function that is checked, an additional uncertainty due to temperature coefficient should be considered if the ambient temperature is different from 25° C. Example: If calibrated at 30°C, add 5°C of temperature coefficient specification.

NOTE

This procedure is intended to verify only the basic accuracy of the Model 172/173 in voltage, current, and resistance modes. Test equipment accuracy should be X10 better than measurement accuracy. In many cases the equipment listed is not X10 better than instrument accuracy because such equipment is not commercially available.

a. Battery Check. (With the Model 1728 Rechargeable Battery Pack installed.)

1. Check for proper installation of individual cells in the battery pack as shown in Figure 7

2. Depress BAT pushbutton.

3. Verify that the "LO BAT" indicator is not lighted. If lighted, recharge batteries.*

b. How to Charge the Batteries. (Perform this procedure only if the batteries are not sufficiently charged.)

1. Set the internal line switch S601 to the appropriate line voltage range.

2. Connect the line cord to the appropriate line voltage.

3. Release LINE and BAT.

4. Recharge for at least 16 hours to fully charge.

c. Input Resistance Check. (DC VOLTS)

1. Depress MAN.

2. Depress BAT.

3. Select the 3 volt DC range using UP RANGE or DN RANGE pushbutton.

4. Measure the input resistance between HI and LO using DMM (F).

5. Input resistance should be >1 x 10^9 ohms. (Make sure that 173 does not read off scale).

6. Select the 30 volt DC range using UP RANGE pushbutton.

7. Measure the input resistance between HI and LO using DMM (F).

8. Input resistance should be 10 megohms ±2½%.

*NOTE

Battery pack may be discharged to the point where the LO BAT indicator circuit will not operate. If in doubt, recharge the battery pack at least 16 hours.

d. Voltage Accuracy Check.

1. DC Voltage.

a) Set to DC Volts and AUTO.

b) Connect the DC Calibrator (A) to the instrument.

c) Set the DC Calibrator to the output specified in Table 6-3.

d) Verify that the instrument reading is within the limits specified.

e) Repeat steps c) and d) with negative voltages.

TABLE 6-3.

DC Voltage Performance Check

Range	Voltage Applied	Allowable Reading (at 25°C) Relative Accuracy*	Absolute Accuracy**
300mV	±0.20000Vdc	±0.19997 to ±0.20003 Vdc	±0.19995 to ±0.20005 Vdc
3V	±2.0000 Vdc	±1.9997 to ±2.0003 Vdc	±1.9996 to ±2.0004 Vdc
30V	±20.000 Vdc	±19.997 to ±20.003 Vdc	±19.996 to ±20.004 Vdc
300V	±200.00 Vdc	±199.97 to ±200.03 Vdc	±199.96 to ±200.04 Vdc
1000V	±1000.0 Vdc	±999.8 to ±1000.2 Vdc	±999.7 to ±1000.3 Vdc

*Does not include the uncertainty of the DC Calibrator.

**Does include the uncertainty of the DC Calibrator.

2. AC Voltage.

a) Set to AC Volts.

b) Set to AUTO.

c) Connect the AC Calibrator (B) to the instrument input terminals.

d) Set the AC Calibrator to the output specified in Table 6-4. Set frequency to 50 Hz, then repeat at 20 KHz.

e) Connect the High Voltage Amplifier (C) to the instrument input terminals.

f) Set the High Voltage Amplifier as shown in Table 6-4.

g) Verify a displayed reading as shown in Table 6-4.

TABLE 6-4.
AC Voltage Performance Check

Range	Voltage Applied	Allowable Reading (at 25°C) Relative Accuracy*	Absolute Accuracy**
300 mV	0.20000 Vrms	0.19964 to 0.20036 Vrms	0.19959 to 0.20041 Vrms
3V	2.0000 Vrms	1.9964 to 2.0036 Vrms	1.9960 to 2.0040 Vrms
30V	20.000 Vrms	19.964 to 20.036 Vrms	19.960 to 20.040 Vrms
300V	200.00 Vrms	199.64 to 200.36 Vrms	199.56 to 200.44 Vrms
1000V	1000.00 Vrms	997.4 to 1002.6 Vrms	997.0 to 1003.0 Vrms

*Does not include the uncertainty of the DC Calibrator.

**Does include the uncertainty of the DC Calibrator

e. Resistance Accuracy Check.

1. High Ohms.

a) Set to Ω (OHMS).

b) Set to HI.

c) Set to 2 WIRE.

d) Set to AUTO.

e) Connect the Decade Resistor (D) to the instrument input terminals.

f) Set the Decade Resistor to the resistance specified in Table 6-5. Verify the readings given.

TABLE 6-5.
Resistance Performance Check (HI OHMS)

Range	Resistance Setting	Allowable Reading (at 25°C) Relative Accuracy*	Absolute Accuracy**
3KΩ	2.0000KΩ	1.9993 to 2.0007K	1.9991 to 2.0009KΩ
30KΩ	20.000KΩ	19.993 to 20.007K	19.991 to 20.009KΩ
300KΩ	200.00KΩ	199.93 to 200.07K	199.91 to 200.09KΩ
3MΩ	2.0000MΩ	1.9991 to 20.009K	1.9989 to 2.0011MΩ
30MΩ	20.000MΩ	19.969 to 2.0031K	19.967 to 20.033MΩ
300MΩ	200.00MΩ	197.99 to 202.01K	197.79 to 202.21MΩ

*Does not include the uncertainty of the Resistance Source.

**Does include the uncertainty of the Resistance Source.

IMPORTANT

Measure the resistance of the leads and subtract from the resistance reading on the Model 172/173.

2. Low Ohms.

a) Set to Ω (OHMS).

b) Set to LO.

c) Set to 2 WIRE.

d) Set to AUTO.

e) Connect the Decade Resistor (D) to the instrument and Ω source terminals.

f) Set the Decade Resistor to the resistance specified in Table 6-6. Verify the readings given.

TABLE 6-6.
Resistance Performance Check (LO OHMS)

Range	Resistance Setting	Allowable Reading (at 25°C)	
		Relative Accuracy*	Absolute Accuracy**
300Ω	200.00	199.93 to 200.07Ω	199.91 to 200.09
3KΩ	2.0000KΩ	1.9993 to 2.0007KΩ	1.9991 to 2.0009KΩ
30KΩ	20.000KΩ	19.993 to 20.007KΩ	19.991 to 20.009KΩ
300KΩ	200.00KΩ	199.91 to 200.09KΩ	199.89 to 200.11KΩ
3MΩ	2.0000MΩ	1.9979 to 2.0021MΩ	1.9977 to 2.0023MΩ
30MΩ	20.000MΩ	19.899 to 20.101MΩ	19.897 to 20.103MΩ

*Does not include the uncertainty of the Resistance Source.

**Does include the uncertainty of the Resistance Source.

IMPORTANT

Measure the resistance of the leads and subtract from the resistance reading on the Model 172/173.

f. Current Accuracy Check. (Model 173 only)

1. DC Current.

a) Set to DC Amperes.,

b) Set to AUTO.

c) Connect Current Source (E) to the instrument input terminals.

d) Set the Current Source to the current specified in Table 6-7. Verify the readings given.

TABLE 6-7.
DC Current Performance Check (Model 173 only)

Range	Current Applied	Allowable Reading (at 25°C) Relative Accuracy*	Absolute Accuracy**
300μA	±200.00μA	199.78 to 200.22μA	199.77 to 200.23μA
3mA	±2.0000mA	1.9978 to 2.0022mA	1.9977 to 2.0023mA
30mA	±20.000mA	19.978 to 20.022mA	19.977 to 20.023mA
300mA	±200.00mA	0.19978 to 0.20022A	0.19858 to 0.20142A
3A	±2.0000A	1.9958 to 2.0042A	1.9838 to 2.0162A

*Does not include the uncertainty of the Current Source.

**Does include the uncertainty of the Current Source.

g. Current Accuracy Check (Model 172 only)

1. DC Current

a) Set to DC Amperes.

b) Set to AUTO.

c) Connect Current Source (E) to the instrument input terminals.

d) Set the Current Source to 200mA. Verify a reading of 199.48 to 200.52mA.*

e) Set the Current Source to the 1A. Verify a reading of 0.9973 to 1.0027A.*

*NOTE

Readings do not account for source inaccuracy. Add 0.02% uncertainty if Current Source (E) is used.

TABLE 6-8.
Summary of Adjustment Controls

Circuit Desig	Description	Paragraph	Schematic Shown
C203	INPUT Current ADJ	6-4 c2 (e)	27904F
C205	OHMS Zero	6-4 c2 (i)	27904F
C817	100V @ 20kHz ADJ	6-4 e7	27903E
C819	1V @ 20 kHz ADJ	6-4 e7	27903E
C820	1KV @ 20 kHz ADJ	6-4 e7	27903E
C821	1KV @ 20 kHz ADJ	6-4 e7	27903E
R103	Auto Cal	6-4 c1 (h)	27904F
R201	Auto Zero	6-4 c1 (i)	27904F
R208	0.3V Ref	6-4 f19	27904F
R209	X10 Gain	6-4 d2 (d)	27904F
R213	2.9V Cal	6-4 d2 (d)	27904F
R217	Buffer Zero	6-4 c1 (j)	27904F
R704	290KΩ ADJ	6-4 f24	27903E
R705	10MΩ ADJ	6-4 f7	27903E
R707	Ω Bias	6-4 f9, 13	27903E
R709	2.9KΩ ADJ	6-4 f29	27903E
R803	1V @ 1kHz ADJ	6-4 e7	27903E
R809	10mV @ 1kHz ADJ	6-4 e7	27903E
R816	100V @ 1kHz ADJ	6-4 e7	27903E
R817	1KV @ 1kHz ADJ	6-4 e7	27903E
R901	1KV DC ADJ	6-4 d2 (d)	27903E
R904	300mV Zero	6-4 d1 (d)	27903E
R911	290V DC ADJ	6-4 d2 (d)	27903E
R913	30V Zero	6-4 d1 (g)	27903E
R506 (173 only)	10mA DC ADJ	6-4 g6	27478D
R509 (173 only)	100mA DC ADJ	6-4 g10	27478D
R512 (173 only)	1A DC ADJ	6-4 g12	27478D

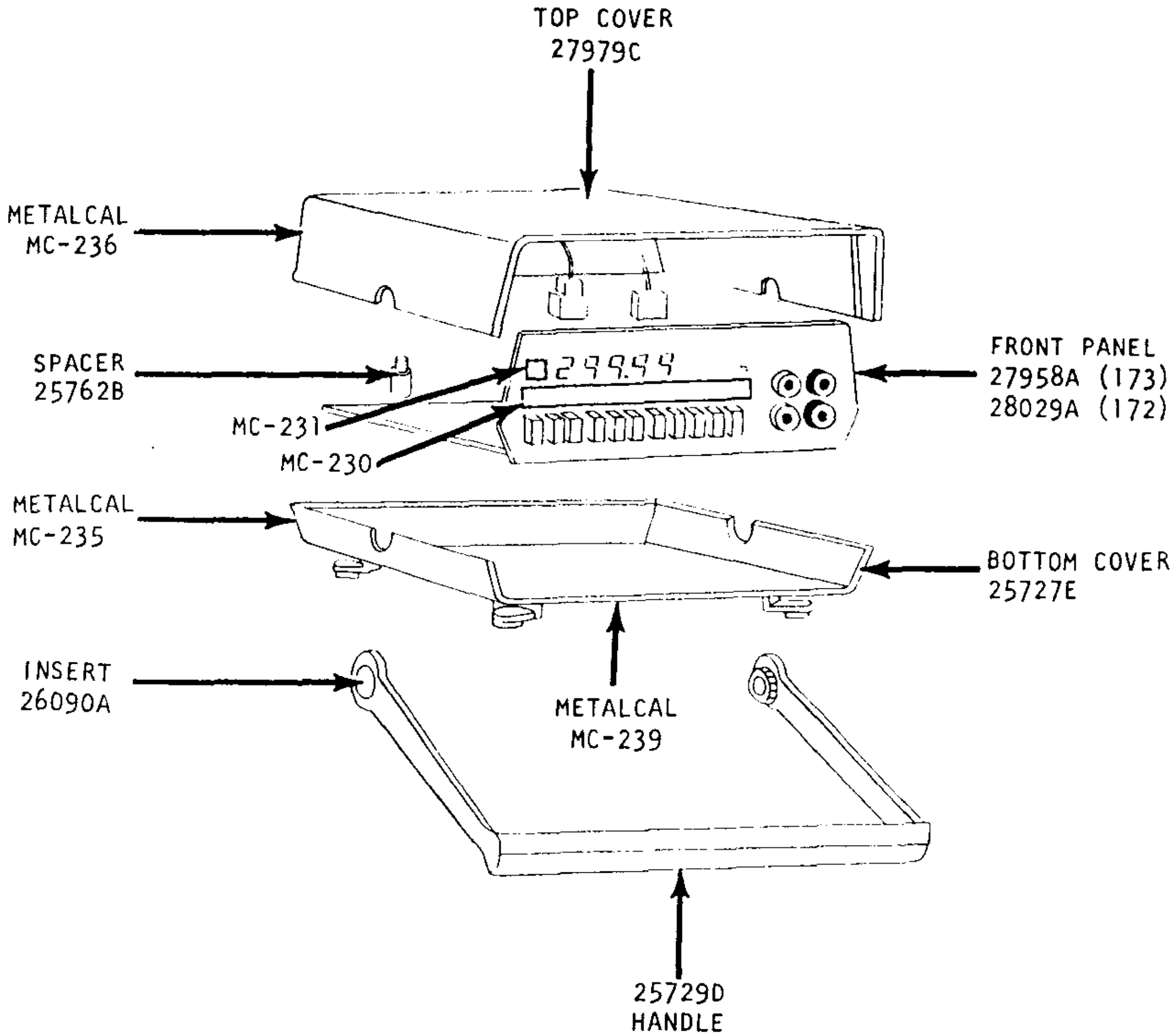


FIGURE 35. Top and Bottom Cover Assembly.

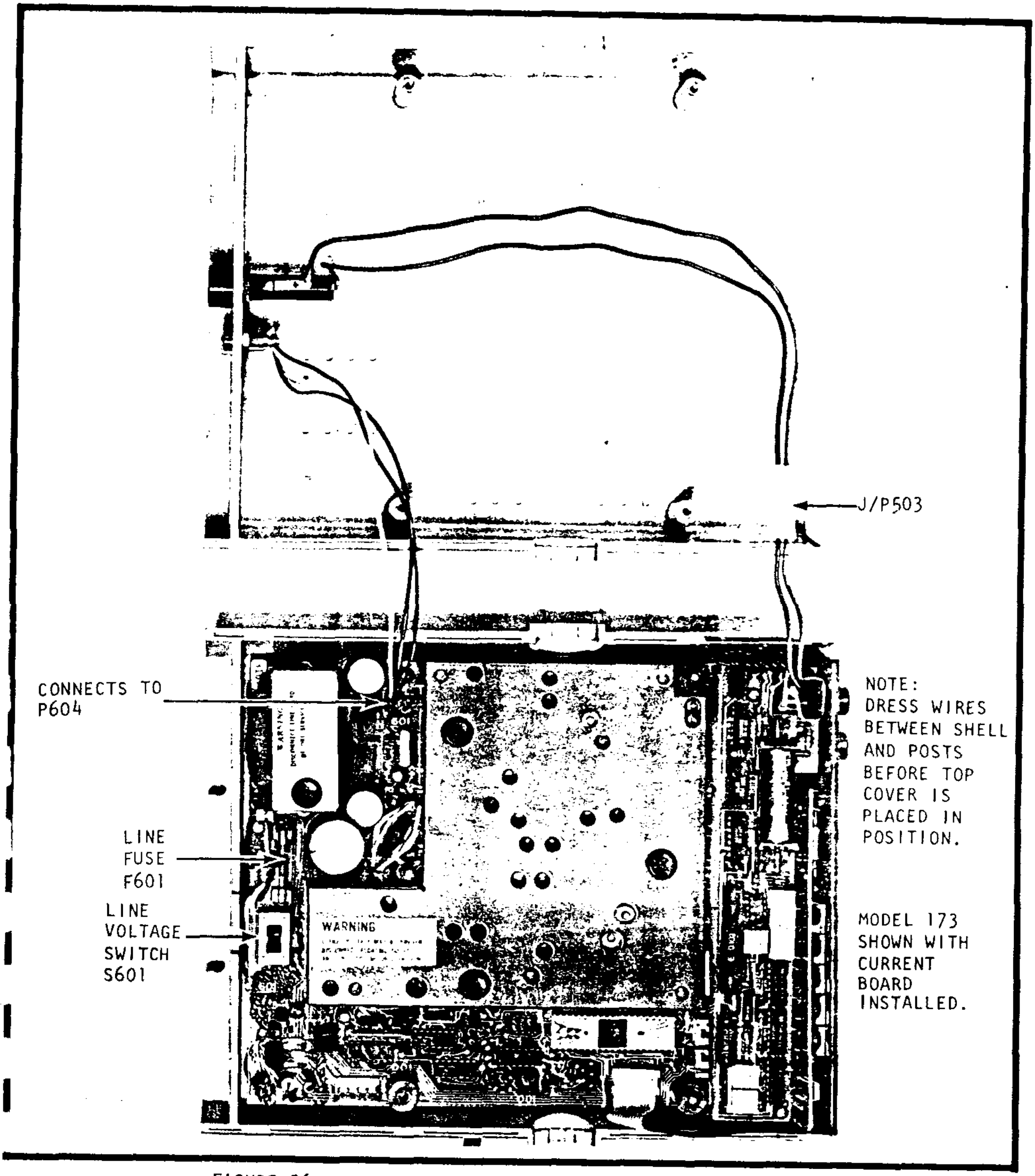


FIGURE 36. Location of Line Fuse and Line Switch.

TABLE 6-9.

List of Test Equipment Required For Adjustment/Calibration

ITEM	DESCRIPTION	MINIMUM SPECIFICATION NEEDED	MFR	MFR MODEL
A	DC Calibrator	+0.290005V, +2.90005V, +29.0005V, +290.005V, +1000.05V, to within 20 ppm	Fluke	343A
B	AC Calibrator	10mV, 1V, 100V, 1000V @ 1kHz 1V, 100V, 1000V @ 20kHz	HP	745A
C	High Voltage Amplifier	See B above	HP	746A
D	Decade Resistor	2KΩ through 20MΩ ±0.01%	ESI	RS725
F	Oscilloscope		TEK	465
G	Current Source*	1A, 100mA, 10mA ± 0.02%	FLUKE	382A
H	DMM	1.0000V ± 0.001%	KI	5900
I	Test Circuit	Resistor, 2MΩ ⎤ Paralleled Capacitor, 1μF ⎦	KI KI	R-253-2M C-215-1μF

*NOTE

An alternate Current Source may be assembled using a precision 1Ω resistor stabilized at constant temperature, and a Keithley Model 227 wiich has been adjusted to obtain a 1.0000 V reading across the 1Ω resistor. Use DMM (H) to accurately monitor the voltage drop.

6-4. ADJUSTMENT/CALIBRATION PROCEDURE. The following adjustments should be performed when a specification has been determined to be out of tolerance. For checking the instrument to its maximum published specifications, the Performance Verification procedure should be used. The "tolerance on reading" is adjusted to allow for time drift of critical components. Ambient temperature should be maintained at 25°C ±1°C.

a. How to Open the Instrument. Turn the instrument over so that the bottom cover is facing up. Loosen the four slotted screws in the bottom panel (the screws are captive and will only unscrew until the screw head is flush with the top of the holes). Turn over the instrument. Carefully lift off the top cover, and disconnect the wires going to the rear panel.

CAUTION

Disconnect the line cord from the line voltage before opening the instrument. Care should be taken to avoid contact with line voltages at various points on the pc board when the line voltage cord is connected. To discharge voltage on capacitors disconnect the line cord and depress LINE.

b. Power Supply Check. The following measurements can be made using the instrument in LINE or BAT modes (if the Model 1728 is installed).

1. Set the internal Line Switch S601 appropriately for the line voltage being used.
2. Using DMM (H) measure the voltages listed in Table 6-10.

TABLE 6-10.
Power Supply Voltage Check

Test Point	Allowable Voltage Range
+5	+4.75V to +5.25V
+15	+14.5 to +15.5
-15	-14.5 to -15.5

NOTE

To achieve calibration to published specifications the instrument should be calibrated using the Model 1725 Calibration Cover. The instrument should be allowed to stabilize for approximately 1 hour after the Calibration Cover is put in place. It is important that the calibration sequence be followed exactly, because the adjustments are interrelated and dependent on prior calibration steps.

c. A/D Calibration.

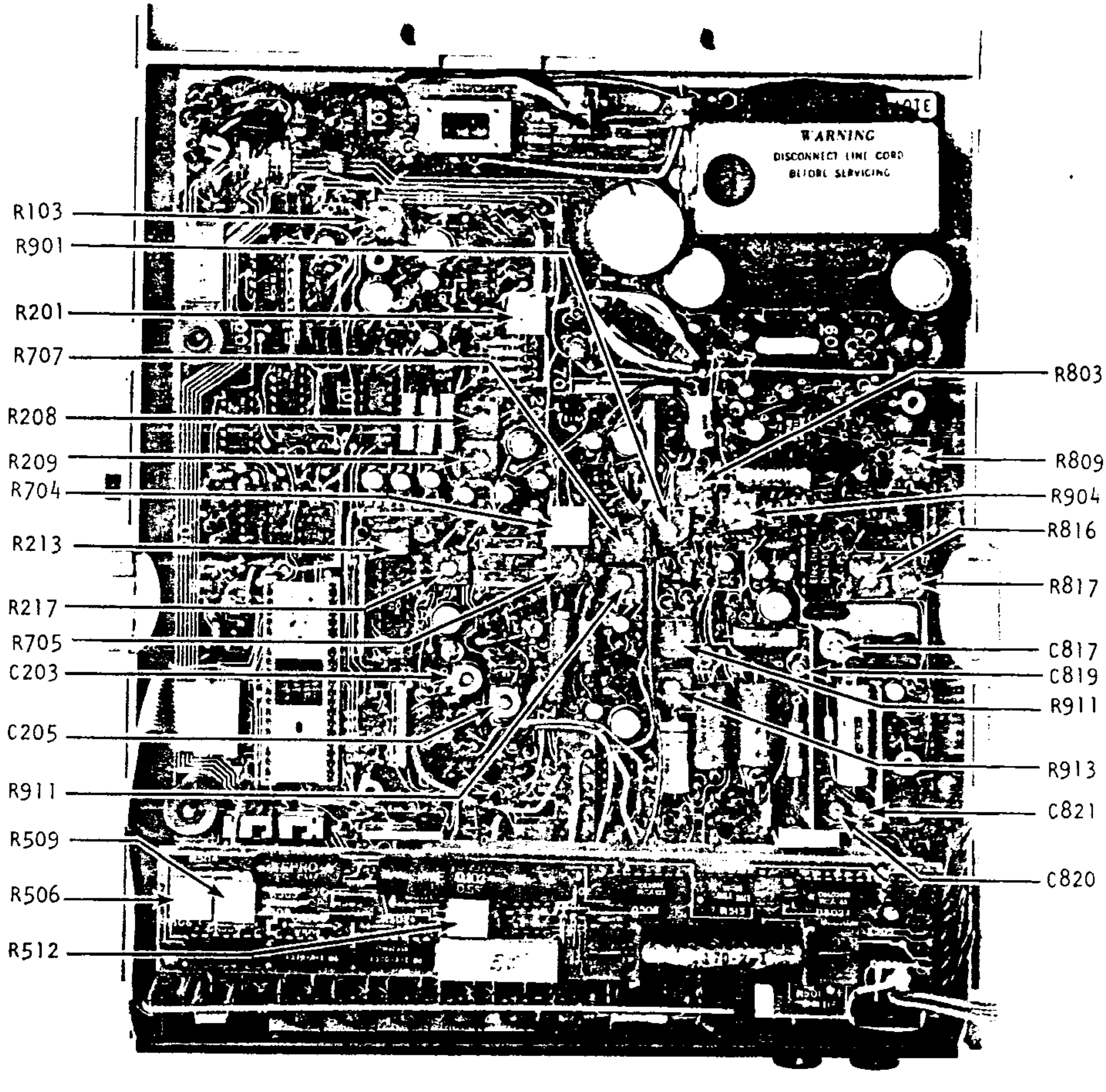
NOTE

This procedure must precede the regular analog section calibration to ensure that the instrument will meet all rated specifications.

1. Capture Range Adjustments.
   a) Set the DMM to MAN.
   b) Set to 300mV DC.
   c) Place a short between input HI and LO.
   d) Connect a Berg-type 2-pin housing (Keithley CS-266) with approx. 30 inch leads at TP101 and TP102 on PC-407 (See Figure 38).
   e) Connect Oscilloscope (G) between the following points.
      1. Oscilloscope Ext. TRIGGER to TP101 (FON).
      2. Oscilloscope VERTICAL INPUT to TP102 (Prefilter).
      3. Oscilloscope GND to signal ground test point J1001A (low).
   f) Set the Oscilloscope controls as follows:
      1. Trigger: +, DC coupled.
      2. Vertical: DC, 0.5 V/division
      3. Time Base: 20 ms/division
   g) For the following adjustments refer to trace shown in Figure 39.
   h) Adjust potentiometer R103 (AUTO CAL ACAL) for a level of +1V ±0.2V during AUTO CAL time period.

IMPORTANT

When adjusting trimmer capacitors C203, C205, C817, C819, C820 and C821 use an insulated screwdriver to avoid shorting to the metal shield. In addition the screwdriver should be rigid so that adjustments can be made with minimum backlash.



Model 173 is shown above (with Current Board Installed.) Model 172 has a 1Ω, Low Resistor (R514) mounted on the metal shield (Not shown).

FIGURE 37. Location of Calibration Adjustments.

Regulator VR603 requires the use of heat sink assembly, Keithley part no. 28203A. If the regulator must be removed, bend the tabs on the heat sink to provide clearance. After a new regulator is installed, bend the heat sink tabs to their original condition to avoid a short circuit to the metal shield or other conducting surfaces adjacent to the regulator.

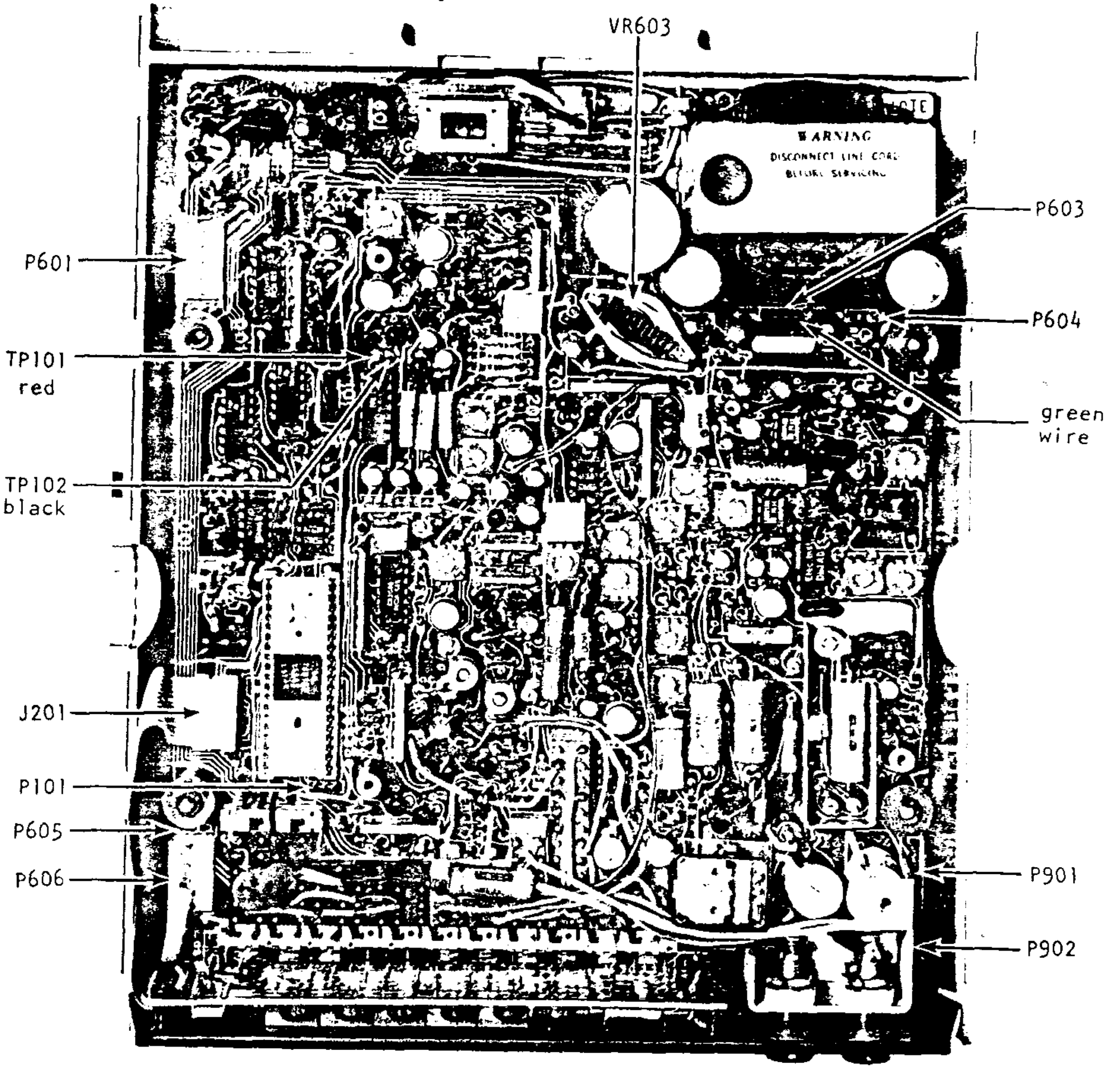


FIGURE 38. Locations of Connectors and Test Points.

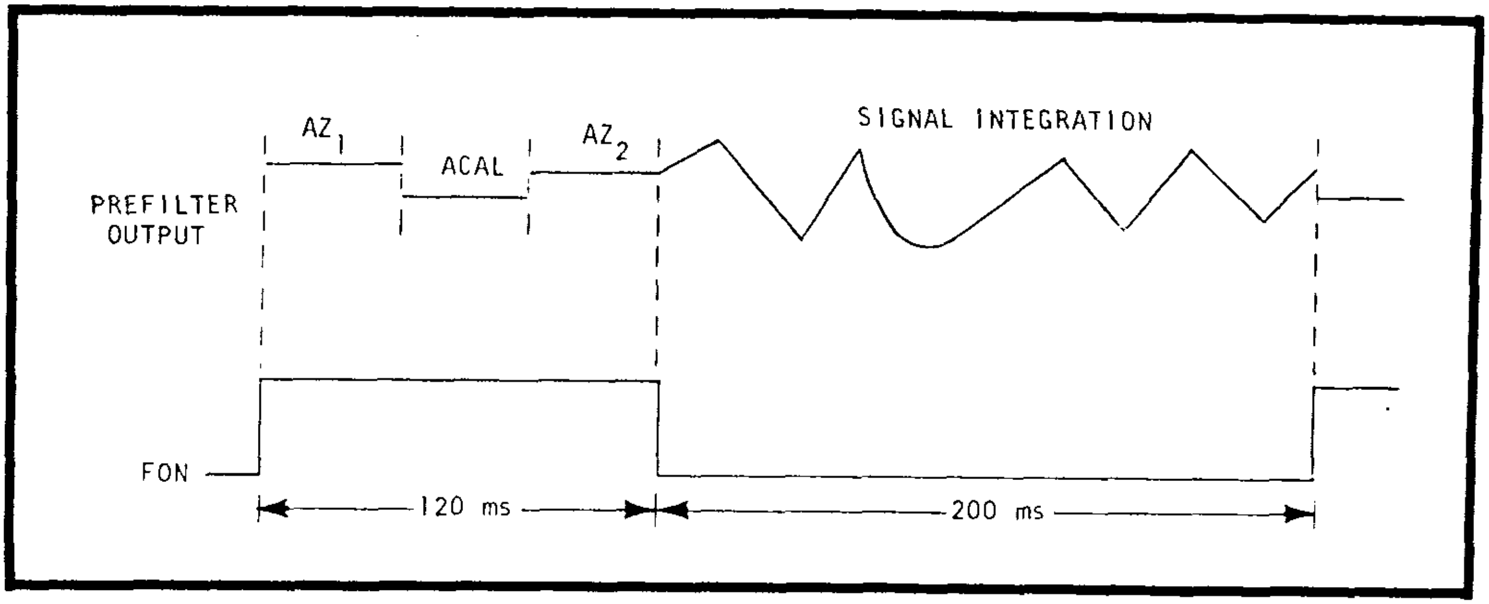


FIGURE 39. Waveform For A/D Calibration

i) Adjust potentiometer R201 (AUTO ZERO AZ_1) for a level of +1V ±0.2V during AZ_1 period.

j) Adjust potentiometer R217 (AUTO ZERO AZ_2) for a level of +1V ±0.2V during AZ_2 Period.

k) Repeat steps h, i, and j until all levels are within 1V ±0.2V simultaneously.

l) Depress HI/LO ohms (Set to LO).

m) Release 2 WIRE/4 WIRE (Set to 2 WIRE).

n) Set range to 3K Ω.

1. Adjust potentiometer R707 (Ω BIAS) for a level of +1V ±0.2V during AUTO ZERO AZ_1 and AUTO ZERO AZ_2 periods.

2. Adjust potentiometer R208 (0.3V Ref) for a level of +1V ±0.2V during AUTO CAL (ACAL) period.

3. Repeat steps 1 and 2 until both conditions are met simultaneously.

2. Zero and Offset Current Adjustments.

a) Set the DMM to 300 mV DC range.

b) Place a short across INPUT HI and LO.

c) Record the reading on the DMM.

d) Remove the short and connect the Test Circuit (H) across input HI and LO.

e) Adjust variable capacitor C203 (Input Current) to obtain the same reading as in step c) to within ± 2 digits.

f) Remove the Test Circuit and replace the short.

g) Set the DMM to 2-WIRE and LO ohms.

h) Set range to 3 KΩ.

i) Adjust variable capacitor C205 (OHMS zero) for a zero reading on the DMM.

j) Set the DMM to 300mV DC.

k) Adjust potentiometer R904 (300 mV Zero) for a zero reading on the DMM.

l) Verify that during the 200 ms INTEGRATION period the output at TP102 (Prefilter) has no more than 10 transitions from positive slope to negative slope (and vice-versa).

d. DC Voltage Calibration. (Depress DC, release V/A, depress AUTO/MAN.)

1. Zero Adjustments.

a) Connect the DC Calibrator to the input terminals.

b) Set the instrument on the 300 mV range by using DOWN RANGE.

NOTE

It may be necessary to compensate for dc offset of the DC Calibrator. For example, if the dc offset is -2 μV dc then the DC Calibrator should be adjusted +2 μV to compensate for the offset. Use a Keithley Model 155.

c) Set the DC Calibrator for an output of +5 μV (see note above).

d) Adjust the "300 mV ZERO" (R904) for a display which flashes between "-0" and "+1".

e) Set the instrument on the 30 V range.

f) Set the DC Calibrator for an output of +.5 mV.

g) Adjust the "30 V ZERO" (R913) for a display which flashes between "-0" and "+1".

2. Full Range Calibration.

a) Connect the DC Calibrator to the input terminals.

b) Set the instrument to the range given in Table 6-11

c) Set the DC Calibrator to the output given in Table 6-11

d) Adjust the control given in Table 6-11 to achieve the display specified.

NOTE

Perform the calibration in the exact order given.

TABLE 6-11
Full Range DC Calibration

ange Setting	Applied Input	Control	Display Required**
3 V	+2.90005 V	2.9 V ADJ (R213)	+2.9000 to +2.9001 V
300 V	+290.005 V	290 V ADJ (R911)	+290.00 to +290.01 V
30 V	+29.0005 V	X10 GAIN (R209)	+29.000 to +29.001 V
1200 V	+1000.05 V	1 KV ADJ (R901)	+1000.0 to +1000.1 V

*The DC Calibrator output should be adjusted to compensate for dc offset voltage.

** Display should flash alternately between readings.

e. AC Voltage Calibration.

1. Depress AC.
2. Release V/A.
3. Depress AUTO/MAN.
4. Connect the AC Calibrator to the input terminals.
5. Set the instrument to the range given in Table 6-12.
6. Set the AC Calibrator for the voltage and frequency given in Table 6-12.
7. Adjust the Control given in Table 6-12 to achieve the display specified.

TABLE 6-12.
Full Range AC Calibration

Range Setting	Applied Input	Frequency	Control	Display Required
* 300 mV	010.00 mV	1 KHz	1 KHz ADJ (R809)	009.99 to 010.01 mV
* 3 V	1.0000 V	1 KHz	1 KHz ADJ (R803)	0.9999 to 1.0001 V
300 V	100.00 V	1 KHz	1 KHz ADJ (R816)	099.99 to 100.01 V
1000 V	1000.0 V	1 KHz	1 KHz ADJ (R817)	999.9 to 1000.1 V
** 1000 V	1000.0 V	20 KHz	20 KHz ADJ (C820, C821)	999.9 to 1000.1 V
** 3 V	1.0000 V	20 KHz	20 KHz ADJ (C819)	0.9999 to 1.0001 V
** 300 V	100.00 V	20 KHz	20 KHz ADJ (C817)	99.99 to 100.01 V

*Repeat these adjustments until both displays are achieved.
**These adjustments are interactive.

f. Ohms Calibration. (Use test leads supplied with Model 1725 Maintenance Kit)

1. Depress Ω.
2. Release HI/LO.
3. Release 2 WIRE/4 WIRE.
4. Release AUTO/MAN.
5. Set the instrument to 30 MΩ range.
6. Connect a shielded 10 megohm resistor to the upper set of terminals.
7. Adjust the 10 MΩ ADJ (R705) for a reading of 10.000 MΩ.
8. Depress HI/LO.
9. Set Ω bias (R707) for 10.000 MΩ (R707).
10. Release HI/LO.
11. Set 10 MΩ ADJ (R705) for 10.000 MΩ.
12. Depress HI/LO.
13. Set Ω bias (R707) for 10.000 MΩ.
14. Connect the Oscilloscope to the test points shown in Figure 38. The "green" wire should be connected between power supply low and Oscilloscope low. The "black" wire should be connected between pre-filter output and Oscilloscope vertical input. The "red" wire should be connected between FON and the Oscilloscope trigger.

15. Set the Oscilloscope to 1V/div. sensitivity and a time base of 20 ms/cm.

16. Set the instrument to 3KΩ range.

17. Depress HI/LO Ohms and release 2 WIRE/4 WIRE.

18. Connect a short across INPUT HI and LO.

19. Adjust 0.3V REF (R208) for +1V ±0.1V during Auto Cal.

20. Verify that level is +1V ±0.3V during Auto Zero. Repeat steps e.2 through e.20 until all conditions are satisfied.

21. Set the instrument to 300KΩ range. (HIΩ)

22. Connect the Decade Resistor (D) to the upper set of terminals.

23. Set the Decade Resistor to 290.000KΩ.

24. Adjust the 290KΩ ADJ (R704) for a reading of 290.00 ±1 digit.

25. Set the instrument to 3KΩ range, HIΩ.

26. Depress 2 WIRE/4 WIRE.

27. Connect the 4-WIRE test cable between the input terminals and Decade Resistor.

28. Set the Decade Resistor to 2.9000KΩ.

29. Adjust the 2.9KΩ ADJ (R709) for a reading of 2.9000KΩ ±1 digit.

g. Current Calibration (Model 173 only).

1. Depress DC.
2. Depress V/A.
3. Depress AUTO/MAN.
4. Set the Model 173 to the 3 ampere range.
5. Connect the Current Source (G) to the Model 173.
6. Adjust the 1 A ADJ (R512) for a reading of 1.0000 A.
7. Set the Model 173 to the 300 mA range.
8. Connect the Current Source to the Model 173.
9. Set the Current Source for (A) for 100.00 mA.
10. Adjust 100 mA ADJ (R509) for a reading of 100.00 mA.
11. Set the Current Source for 10.00 mA.
12. Adjust 10 mA ADJ (R506) for a reading of 10.000 mA.

h. Current Calibration For Model 172. No adjustments can be made. Primary component which determines accuracy is resistor R514 (1Ω, 0.1%, 10W, WW).

6-5. TROUBLESHOOTING AND REPAIR. An understanding of basic analog and digital circuit fundamentals is needed to troubleshoot and repair the Model 172/173. It is strongly recommended that the user review the Theory of Operation (Section 5) and the Adjustment/Calibration procedure (paragraph 6-4) before any attempt is made to repair the Model 172/173.

a. Troubleshooting Hints. Table 6-13 describes the Symptoms and Probable Faulty Component for a variety of possible malfunctions. It is beyond the scope of this Instruction Manual to list all possible symptoms. Therefore, the Keithley represenative in your area should be contacted in the event repair is needed. For In-Warranty repairs within the continental U.S.A. contact the factory for shipping instructions.

TABLE 6-13
Troubleshooting Hints

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
a) No display (LINE mode)	1) Line switch set incorrectly.	Check connection to line power. Check LINE switch setting to conform to line voltage available. See Figure 36.
	2) Fuse F101 is missing or open.	Check fuse. Replace with proper rating.
	3) Line voltage connector J601 improperly connected to pc board at P601.	Check connection to pc board as shown in Figure 39.
b) No display. (BAT mode)	4) Batteries need recharging. (Check for LO BAT indication.)	Connect instrument to line power. Release LINE.
	2) Battery fuses blown.	Check F401, F402, and F403.
	3) Batteries improperly installed on battery pack.	Check battery pack for proper polarity on all batteries. See Figure 7.
	4. Battery cables improperly installed.	Check battery connections at P602 and R606. as in Figure 7.
c) No display (All modes)	1) Display cable P301 not properly connected.	Check plug P301 and mating connector J201. Make certain all pins are making proper contact (pins should not be bent). Check for proper orientation of the connector
	2) LSI module improperly installed.	Check U103 for proper installation. Make certain all pins are making contact (pins should not be bent).
	3) Power supply malfunction.	Check power supply voltages as described in Section 6-4b.
d) Display is blank. or some segment on.	1) Clock waveform is missing.	Check pin 4 of LSI (U103) for a clock waveform of approx. 334 kHz, swinging between +4V and ØV. If waveform is present LSI U103 is probably faulty. If waveform is not present, integrated circuits U003, U004, transistor Q003, or ceramic resonator CR003 may be faulty.

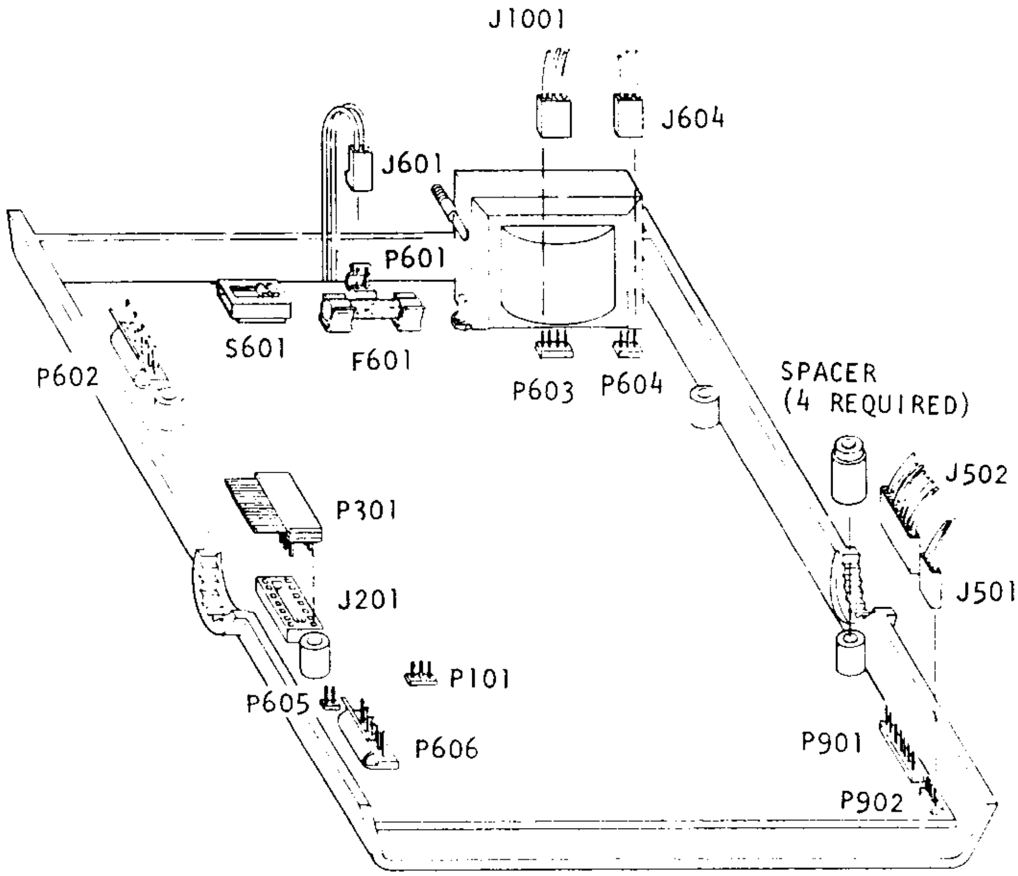


FIGURE 40. Plug-In Connections on PC-407

TABLE 6-13 (Con't)
Troubleshooting Hints

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
e) One display bar missing on all digits.	1) Faulty connection between P301 and J201.	Check plug P301 and mating connector J201. Make certain all pins are making contact.
	2) Cathode driver circuitry faulty. See schematic 27404D	"a" bar: Check R302 pin 14 for signal. When "ON", voltage should be approx. +1.8V. "b" bar: Check R302 pin 16 "c" bar: Check R302 pin 15 "d" bar: Check R302 pin 9 'e" bar: Check R302 pin 12 "f" bar: Check R302 pin 10 "g" bar: Check R302 pin 13 decimal point: Check R302 pin 11
f) One digit missing.	1) Faulty connection between R301 and J201.	Check plug P301 and mating connector J201.
	2) Anode driver circuitry faulty. See schematic 27404D.	If units digit missing, check collector of Q305 for signal. When "ON", voltage should be approx. 4.8V. If tens digit missing, check collector of Q304. If hundreds digit missing, check collector Q303. If thousands digit, minus sign and function indicator missing, check collector Q302.
g) 10,000 digit missing. (except if reading is less than 10,000 counts)	Q301	On 10,000 digit, check collector Q301. If no signals are present problem could be transistor or integrated circuit U301.
h) Function indicator off.	Transistor Q306	
i) Faulty reading on Ω function.	1) DMM set for 4 WIRE ohms and Ω SOURCE terminals are not connected.	Set to 2 WIRE.
	2) DMM set for 4 WIRE ohms, but leads are reversed.	Connect HI input to the same side of unknown as the + Ω SOURCE lead.
j) Faulty reading on Current function.	Current fuse F501 is blown.	Replace fuse on rear panel.

b. How to Repair Circuits and/or Components Which Have a "Conformal Coat". The Model 172/173 circuit board has a conformal coat which protects the circuit from moisture, and enables the 172/173 to function over a range of environmental conditions.

1. The circuits and/or components are covered by a Conformal Coating manufactured by Dow Corning Corporation. Dow Corning® QR4-3117 Conformal Coating is a transparent, one-part silicone elastoplastic resin.

2. Parts coated with QR4-3117 coating can be repaired by either of two methods.

a) Apply a small amount of solvent (see below) and allow the coating to dissolve. After cleaning, make the repair (unsolder component, etc.). Recoat with Conformal Coating.

b) For minor repairs, a soldering iron can be used to melt through the coating to unsolder or resolder a component lead. After cleaning the soldered area, recoat with Conformal Coating.

3. Cleaning may be accomplished using a small brush or cotton swab and solvent, such as FREON-TE, TOLUENE, XYLENE OR CHLOROTHENE.

CAUTION

Use solvent on circuit tape side only. Solvent may adversely affect components.

4. Recoat with undiluted Conformal Coating using a small brush or other applicator.

5. Shelf life of the coating material is approximately 12 months. Always use fresh coating material in order to maintain the properties of the material.

WARNING

The Conformal Coating is combustible. Keep away from heat and open flame. Use with adequate ventilation. Avoid prolonged breathing of vapor. Avoid prolonged or repeated skin contact. Take necessary precautions when using cleaning solvents. See applicable manufacturers data sheets.

SECTION 7. REPLACEABLE PARTS

7-1. GENERAL. This section contains information for ordering replacement parts. The parts list is arranged in alphabetical order of their Circuit Designations.

7-2. ORDERING INFORMATION. To place an order or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover of the catalog for addresses. When ordering, include the following information.

a. Instrument Model Number

b. Instrument Serial Number

c. Part Description

d. Circuit Designation (if applicable)

e. Keithley Part Number

7-3. SCHEMATICS.

a. Input Signal Conditioning. (28656E, Sheet 1 of 3). This schematic describes the input switching, ac/dc conversion, filtering, attenuating, and ohms source. Circuit designation series is 700, 800, and 900.

b. A/D Converter (28656E, Sheet 2 of 3). This schematic describes the analog-to-digital converter and the range selection circuitry. Circuit designation series is 000, 100, and 200.

c. Display (27404D). This schematic describes the display driver circuitry. Circuit designation series is 300.

d. Power Supply (28656E, Sheet 3 of 3). This schematic describes the line power supply. Circuit designation series is 600. (See schematic 26758C for the Model 1728 Rechargeable Battery Pack.)

e. Current Board (27478D). This schematic describes the current circuitry for both the Models 172 and 173. Circuit designation series is 500.

f. Model 1728 Rechargeable Battery Pack (26758C). Circuit designation series is 400.

g. Digital Interface, Bottom (27902E). This schematic describes the Model 1722 circuitry. Circuit designation series is 1000.

h. Digital Interface, Upper (28019E). This schematic describes the Model 1722 circuitry. Circuit designation series is 1100.

i. Timing Diagrams for Model 1722. (28247E, 28248E, 28249D).

TABLE 7-1
Cross-Reference of Manufacturers

MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE	MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE
A-B	Allen-Bradley Corp. Milwaukee, WI 53204	01121	CLR	Clarostat Mfg. Co., Inc. Dover, NH 03820	12697
A-D	Analog Devices Inc. Cambridge, MA 02142	24355	CTS	CTS Corporation Elkhart, IN 46514	71450
AMP	Amp Inc. Harrisburg, PA 17105	00779	DIC	Dickson Electronics Corp. Scottsdale, AZ 85252	12954
APH	Amphenol Broadview, IL 60153	02660	DTN	Dielettron (Consolidated) New York City, NY 10013	
APX	Amperex Elkgrove Vlg, IL 60007	73445	ECI	Electro Cube Inc. San Gabriel, CA 91776	14752
BEC	Beckman Inst. Inc. Fullerton, CA 92634	73138	EDI	Electronic Devices Inc. Yonkers, NY 10710	
BLD	Belden Mfg. Co. Chicago, IL 60644	70903	EFJ	E F Johnson Co. Waseca, MN 56093	74970
BRG	Berg Electronics Inc. New Cumberland, PA 17070	22526	ERI	Erie Technological Prod. Erie, PA 16512	72982
BRN	Bourns, Inc. Riverside, CA 92507	80294	F-I	Fairchild Inst Corp. Mountain View, CA 94043	07263
BUS	Bussman Mfg. Div. St. Louis, MO 63017	71400	FUS	Bussman Mfg. (Fusetron) St. Louis, MO 63107	71400
C-I	Components, Inc. Biddeford, ME 04005	06751	G-E	General Electric Company Syracuse, NY 13201	03508
C-W	Continental-Wirt Elec. Corp. Warminster, PA 18974	79727	G-I	General Instrument Corp. Newark, NJ 07104	72699
CAD	Caddock Riverside, CA 92507	19647	GLD	Gould, Inc. St. Paul, MN 55165	52431
CAN	ITT Cannon Electric Santa Ana, CA 92702		H-P	Hewlett-Packard Palo Alto, CA 94304	50434
CLB	Centralab Division Milwaukee, WI 53201	71590	DLE	Dale Electronics Inc. Columbus, NE 68601	91637

TABLE 7-1 (Cont'd)

MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE	MFR. CODE	NAME AND ADDRESS	FEDERAL SUPPLY CODE
INT	Intersil Inc. Cupertino, CA 95014	32293	RCL	RCL Electronics, Inc. Manchester, NH 03102	01686
IRC	IRC Division Burlington, IA 52601	07716	SIE	Siemens Corporation Iselin, NJ 08830	25088
K-I	Keithley Instruments, Inc. Cleveland, Ohio 44139	80164	SIG	Signetics Corp. Sunnyvale, CA 94086	18324
L-F	Littlefuse, Inc. Des Plaines, IL 60016	75915	SIL	Siliconix Inc. Santa Clara, CA 95054	17856
MOL	Molex Downers Grove, IL 60515	27264	SPG	Sprague Electric Co. Visalia, CA 93278	14659
MOT	Motorola Semi Prod. Inc. Phoenix, AZ 85008	04713	T-I	Texas Instruments, Inc. Dallas, TX 75231	01295
NAT	National Semi Corp. Santa Clara, CA 95051	27014	TEP	Tepro Electric Corp. Rochester, NY 14606	02985
P&B	Potter & Brumfield Princeton, IN 47670		TPL	Temple Tecate, CA 92080	29505
PAK	Paktron Vienna, VA 22180		TRW	TRW Capacitor Div. Ogallala, NB 69153	84411
POM	Pomona Electric Pomona, CA 91766	05276	VIS	Vishay Resistor Products Malvern, PA 19355	18612
QTN	Q-Tron Santa Ana, CA 92705		VRN	Vernitron Laconia, NH 03246	13150
RAY	Raytheon Company Quincy, MA	94144	WAB	Wabash-Magnetics Wabash, IN 46992	01101
RCA	RCA Corporation Moorestown, NJ 08050	02734			

BATTERIES (BT)

"400" SERIES (Schematic 26758C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
BT401	Multicell, 19.2V, Nickel-Cadmium	GLD	403041	BA-31
BT402	Multicell, 19.2V, Nickel-Cadmium	GLD	403041	BA-31
T403	Set of Seven "C" cells, 8.4 Volts	--	--	*
*	Nickel-Cadmium, "C" cell, 1.2 volts (used for BT403; seven required)	GLD	2.0SCB	BA-30

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 28656E)			
C001	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
002	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
003	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C004	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C005	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
006	33pF, 1000V, CerD	CLB	DD-330	C-64-33P
C007	0.01μF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C008	0.01 μF, 16V, CerD	CLB	UK16-103	C-238-.01M
009	2.2 μF, 20V, ETT	C-1	TD1-20-225-20	C-179-2.2M
C010	0.47μF, Sov, Cer Film	ERI	8131050651474M	C-237-0.47M
	"100" SERIES (Schematic 28656E)			
C101	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
102	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C103	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C104	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
105	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
106	0.022 μF, 50V, MPC	ECI	625B1A223-J	C-201-.022M
C107	.0022 μF, 200V, My, 10%	E-C	625B1C222	C-221-.0022M
C108	0.01 μF, 100V, My, 10%	PAK	PT420	C-38-.01M
109	33 pF, 1000V, CerD	CLB	DD-330	C-64-33P
C110	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C111	0.1 μF, 16V, CerD.	CLB	UK16-104	C-238-.1M
C112	0.22 μF, 50V, MPC.	ECI	625B1A224J	C-201-.22M
C113	0.22 μF, 50V, MPC.	ECI	625B1A224J	C-201-.22M
C114	0.22 μF, 50V, MPC.	ECI	625B1A224J	C-201-.22M
C115	8.2 pF, 50V, Cer	CLB	C40C8R2K	C-282-8.2P

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 28656E)			
C201	15 pF, 1000V, CerD	CLB	DD-150	C-64-15P
C202	2.2 µF, 20V, ETT	C-I	TD1-20-225-20	C-179-2.2M
C203	.8-11 pF, 1000V, HI-K, Glass	SPG	GHC11000	C-202-.8-11P
C204	3.3pF, 50V, Cer	CLB	C40C3R3D	C-282-3.3P
C205	.8-11 pF, 1000V, HI-K, Glass	SPG	GHC11000	C-202-.8-11P
C206	0.0022µF, 200V, MPC	E-C	625B1C222	C-221-.0022M
C207	100 pF, 1000V, CerD	CLB	DD-101	C-64-100P
C208	100 pF, 1000V, CerD	CLB	DD-101	C-64-100P
C209	100 pF, 1000V, CerD	CLB	DD-101	C-64-100P
C210	1500 pF, 1000V, CerD	CLB	DD-152	C-64-1500P
	"300" SERIES (Schematic 27404D)			
C301	180µF, 20%, 6V	DIC	D180EC6M1	C-270-180M
C302	0.01µF, 16V, CerD	CLB	UK16-103	C-238-.01M
	"500" SERIES (Schematic 27478D)			
C501	47 pF, 1000V, CerD	CLB	DD-470	C-64-47P
	"600" SERIES (Schematic 28067D)			
C601	270 µF, 6V, ETT	C-I	TD5-506277-20	C-194-270M
C602	10 µF, 20V, ETT	C-I	TD2-20-106-20	C-179-10M
C603	10 µF, 20V, ETT	C-I	TD2-20-106-20	C-179-10M
C604	10 µF, 20V, ETT	C-I	TD2-20-106-20	C-179-10M
C605	2000 µF, 25V	RIC	JC-P-2000-25-8P	C-255-2000M
C606	0.47 µF, 20V, ETT	C-I	TD1-20-474-20	C-179-.47M
C607	470 µF, 50V, EAL	TPL	411-470µF	C-246-470M
C608	10 µF, 20V, ETT	C-I	TD2-20-106-20	C-179-10M
C609	10 µF, 20V, ETT	C-I	TD2-20-106-20	C-179-10M
C610	0.1µF, 50V, CerF	EDI	812105061-104M	C-237-0.1M
C611	470 µF, 50V, EAL	TPL	411-470µF	C-246-470M
C612	0.1µF, 50V, CerF	EDI	812105061-104M	C-237-0.1M
	"700" SERIES (Schematic 28656E)			
C701	100 pF, 1000V, CerD	CLB	DD-101	C-64-100P
C702	1500 pF, 500V, Poly	CLB	CPR-1500J	C-138-1500P

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 28019E)			
U1101	Hex Inverters, Open Collector Output. . . .	TEXAS	SN74LS05N	IC-141
U1102	Hex Inverters, Open Collector Output. . . .	TEXAS	SN74LS05N	IC-141
U1103	Hex Inverters, Open Collector Output. . . .	TEXAS	SN74LS05N	IC-141
U1104	Positive-NAND Gates and Inverters/ Totem-pole outputs	TEXAS	SN74LS14N	IC-137
U1105	Hex Inverters, Open Collector Output . . .	TEXAS	SN74LS05N	IC-141
U1106	Dual D-Type Flip-Flop, 14-pin DIP.	RCA	CD4013AE	IC-103
U1107	Quad 2-Input NOR, 14-pin DIP	RCA	CD4001AE	IC-108
U1108	COS/MOS 8-Stage Static Shift Register	RCA	CD4021AE	IC-130
U1109	Quad 2-Input AND, 14-pin DIP	RCA	CD4081BE	IC-138
U1110	COS/MOS Dual 4 Input NAND Gates.	RCA	CD4012AE	IC-140
U1111	Six COS/MOS Hex Inverter	RCA	CD4069BE	IC-139

VOLTAGE REGULATORS (VR)

Circuit Desig.	Description	Mfr. Code	MFR. Desig.	Keithley Part No.
	"100" SERIES (Schematic 28656E)			
VR101	Zener, 9.1V, 400mW	DIC	1N960B	DZ-55
VR102	Zener, 6.2V, 1/4W.	DIC	1N827A	DZ-48
	"200" SERIES (Schematic 28656E)			
VR201	Zener, 6.2V, 1/4W - Part of matched set 28040B			
VR202	Zener, 9V - Part of matched set 28040B			
VR203	Zener, 12V, 400mV	DIC	1N963B	DZ-54
	"600" SERIES (Schematic 28656E)			
VR601	Voltage Regulator, +8V, Case TO-92	NAT	LM340LAZ-8.0	IC-164
VR602	Regulator, 5v, Case TO-220 (IC-93).	F-1	UGH7805393	28515A
VR603	Regulator, ±15V, TO-66 Case	RAY	RC4195TK	IC-128
	"800" SERIES (Schematic 28656E)			
VR801	Zener, 12V, 400mW	DIC	1N963B	DZ-54

JUMPERS (W)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 28656E)			
W201		K-1	---	J-3
	"500" SERIES (Schematic 28656E)			
W501		K-1		J-3
	"600" SERIES (SCHEMATIC 28656E)			
W601		K-1		J-3
	"800" SERIES (SCHEMATIC 28656E)			
W801		K-1	--	J-3
	"900" SERIES (Schematic 28656E)			
W901	(Used only on Model 173)	K-1	--	WIRE

MISCELLANEOUS

DESCRIPTION	KEITHLEY PART NO.
Top Cover (less metalcal)	27979C
. . Metalcal for top cover	MC-236
Bottom Cover (less metalcals)	25727E
. . Metalcal, operating instructions	MC-239
. . Metalcal, rear panel	MC-235
Handle (less insert)	25729D
. . Insert (2 req'd)	26090A
Spacer (4 req'd)	25762B
Rubber foot (4 req'd)	FE-10
Front Panel - Model 172	28029A
Front Panel - Model 173	27958A
"O" Ring (Used to hold display board)	GA-18

TABLE 7-2
COMPONENT DESIGNATIONS FOR PC-407 (MODEL 173)
(See Figure 43.)

Circuit Desig.	Location Code
C001	G-27
C002	G-27
C003	K-26
C004	M-26
C005	M-25
C006	S-29
C007	U-29
C008	T-26
C009	U-27
C101	G-26
C102	H-22
C103	F-18
C104	G-18
C105	H-18
C106	K-23
C107	K-22
C108	L-21
C109	K-19
C110	M-24
C111	P-26
C112	Q-22
C113	Q-22
C114	Q-20
C115	T-20
C201	Y-19
C202	a-23
C203	a-20
C204	a-21
C205	a-18
C206	a-17
C207	c-18
C208	d-17
C209	e-21
C210	f-24
C601	B-28
C602	B-26
C603	D-25
C604	L-15
C605	F-13
C606	J-13
C607	J-11
C608	L-10
C609	L-10
C610	L-8
C611	J-2
C612	I-14
C701	T-14
C702	Z-15
C801	P-10
C802	N-8
C803	Q-9
C804	R-9
C805	N-7
C806	N-5
C807	R-8
C808	R-5
C809	S-5
C810	P-2
C811	U-7
C812	V-8
C813	V-7
C814	T-3
C815	X-10
C816	X-5
C817	Y-5
C818	X-3
C819	Z-6
C820	f-5
C821	f-4
C901	V-11
C902	D-19
C903	f-14
C904	g-14
C905	g-12
C906	g-7
C907	h-6
C908	g-3
C909 (NS)	k-26
C910 (NS)	h-24
CR001	J-26
CR002	L-26
CR003	W-30
CR201	U-19
CR202	V-17
CR203	V-19
CR204	V-18
CR205	W-21
CR206	Y-17
CR207	Y-23
CR208	b-23
CR209	c-23
CR210	c-23
CR211	d-23
CR212	d-23
CR213	H-33
CR214	W-18
CR601	J-8
CR602	J-5
CR701	P-14
CR702	P-13
CR703	S-13
CR704	Y-13
CR705	e-16
CR801	Q-5
CR802	V-5
CR803	a-2
CR804	b-2
CR901	W-9
CR902	g-9
CR903	h-19
CR904 (NS)	m-23
CR905 (NS)	m-24
DS601	p-30
F601	C-16
J201	b-30
K801	U-6
K901	K-9
P101	e-25
P601	H-31
P602	B-16
P603	K-7
P604	K-4
P605	g-31
P606	k-31
P901	k-1
P902	p-1

TABLE 7-2 (continued)
Component Designations For PC-407

Circuit Desig.	Location Code
Q001	H-25
Q002	R-25
Q003	V-29
Q101	F-19
Q102	H-21
Q103	J-22
Q104	J-21
Q105	K-24
Q106	L-23
Q107	L-21
Q108	M-22
Q109	M-21
Q110	S-23
Q111	S-22
Q112	S-21
Q113	S-20
Q201	L-20
Q202	S-18
Q203	S-17
Q204	T-18
Q205	T-17
Q206	X-19
Q207	X-17
Q208	Y-19
Q209	b-22
Q210	b-20
Q211	d-21
Q212	d-20
Q213	d-19
Q214	f-22
Q215	f-21
Q216	h-22
Q701	P-16
Q702	P-15
Q703	Q-15
Q704	Q-14
Q705	P-12
Q706	Q-12
Q707	X-14
Q708	Z-14
Q709	a-14
Q710	b-15

Circuit Desig.	Location Code
Q801	P-9
Q802	N-6
Q803	P-4
Q804	Q-9
Q805	b-3
Q901	V-10
Q902	e-9
Q903	f-10
R001	H-27
R002	J-27
R003	Q-27
R004	R-27
R005	S-26
R006	S-30
R007	T-30
R008	S-29
R009	U-30
R010	V-29
R011	X-30
R012	Y-29
R013	T-27
R101	H-27
R102	F-25
R103	F-23
R104	F-21
R105	F-18
R106	H-20
R107	G-19
R108	H-18
R109	H-17
R110	T-23
R111	X-26
R112	X-27
R113	Z-26
R114	Z-27
R201	K-17
R202	L-19
R203	L-18
R204	M-18
R205	M-18
R206	N-18
R207	P-18
R208	P-19

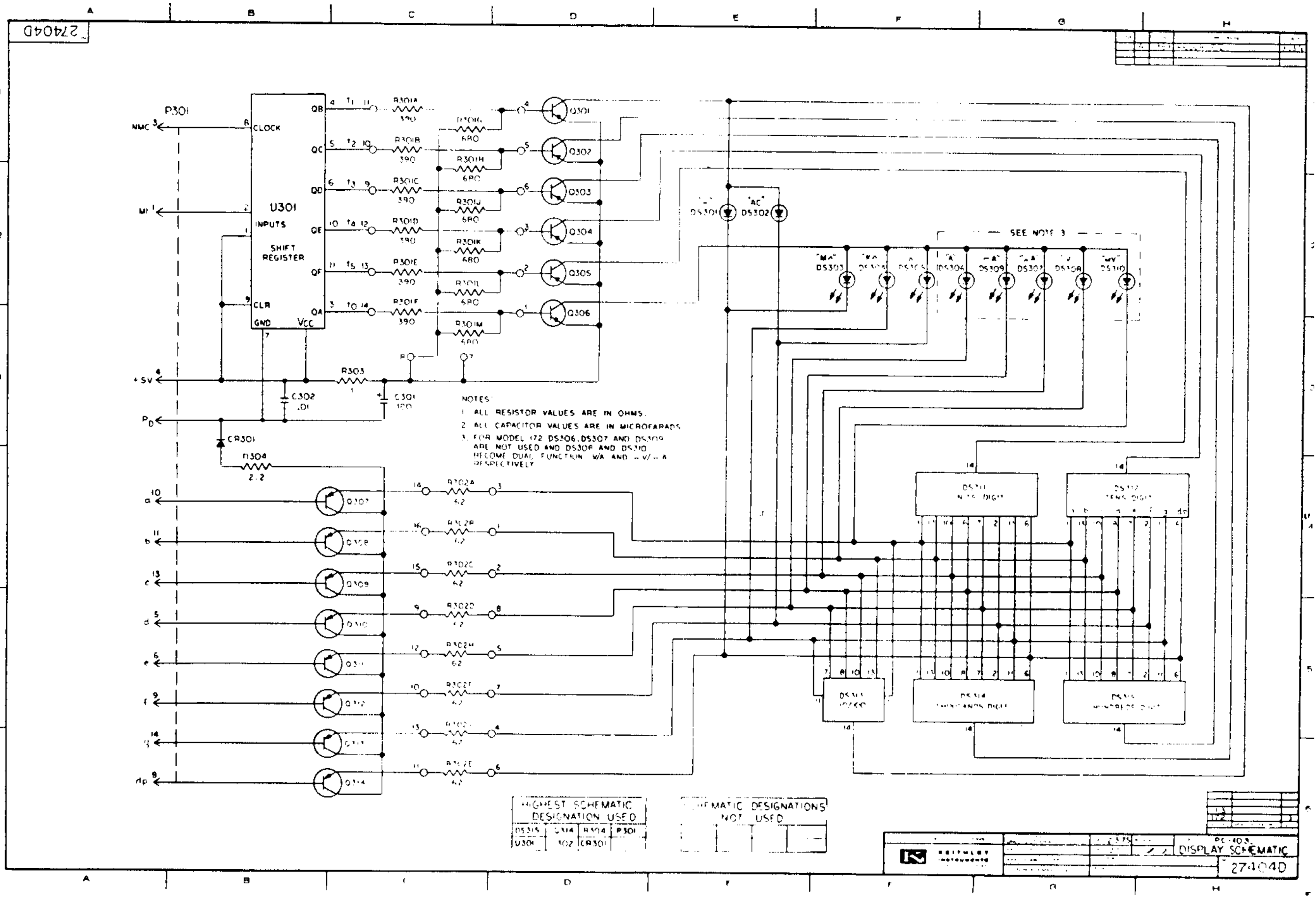
Circuit Desig.	Location Code
R209	R-19
R210	Q-18
R211	U-24
R212	U-21
R213	U-23
R214	U-18
R215	W-24
R216	V-21
R217	V-20
R218	W-18
R219	Y-21
R220	X-18
R221	Z-23
R222	Z-18
R223	b-24
R224	b-22
R225	b-18
R226	d-18
R227 (NS)	d-20
R228	e-17
R229	g-24
R230	g-22
R231	e-28
R601	B-30
R602	B-31
R603	C-30
R604	D-31
R605	E-30
R606	D-27
R607	L-4
R608	L-4
R609	M-4
R610 (NS)	k-28
R611	p-26
R612	M-10
R613	M-9
R701	N-15
R702	P-13
R703	R-13
R704	U-16
R705	V-16
R706	U-15
R707	U-13
R708	V-15
R709	W-14
R710	Y-16

TABLE 7-2 (continued)
Component Designations For PC-407

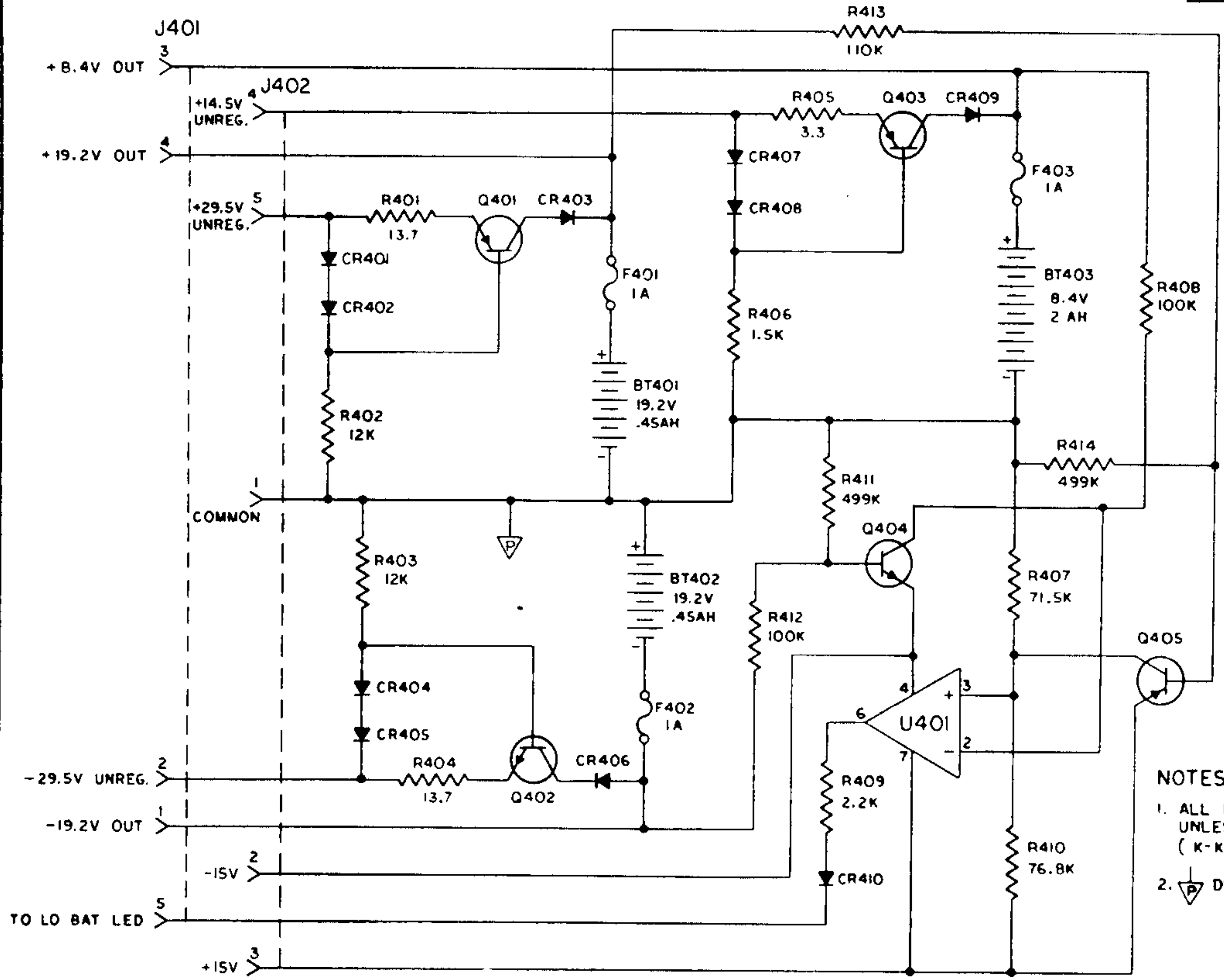
Circuit Desig.	Location Code
R801	N-10
R802	P-9
R803	S-11
R804	P-6
R805	N-4
R806	Q-4
R807	R-4
R808	R-3
R809	R-2
R810	T-6
R811	T-6
R812	T-5
R813	X-9
R814	Y-8
R815	W-5
R816	V-4
R817	W-2
R818	b-4
R819	Z-2
R820	c-2
R901	U-12
R902	T-11
R903	U-11
R904	T-9
R905	U-10
R906	U-9
R907	NOT USED
R908	NOT USED
R909	X-12
R910	W-11
R911	Y-12
R912	Z-12
R913	a-12
R914	NOT USED
R915	b-8
R916	c-7
R917	d-12
R918	e-12
R919	e-11
R920	e-10
R921	f-12
R922	f-11
R923	g-5
R924	e-18
R925	f-19
R926	f-18

Circuit Desig.	Location Code
R927 (NS)	k-17
R928 (NS)	g-15
R929 (NS)	n-16
R930	p-20
R931	p-20
S601	B-20
T601	D-7
TP101	M-23
TP102	M-24
U001	J-28
U002	N-27
U003	Q-29
U004	U-28
U005	U-26
U101	H-20
U102	P-24
U103	a-26
U201	W-23
U202	X-20
U701	S-15
U702	b-13
U901	d-14
VR001	X-29
VR101	F-26
VR102	G-21
VR201	L-19
VR202	N-18
VR203	Z-23
VR601	B-25
VR602	F-16
VR603	L-13
VR801	Y-9
W201	P-18
W601	D-29
W602	D-29

Circuit Desig.	Location Code
W603	E-28
W604	E-28
W605	D-27
W606	D-27
W607	L-9
W801	C-5
W901	f-19


27404D
P301
NMC
MI
+5V
PD
CR301
R304 2.2
U301
INPUTS
SHIFT REGISTER
CLOCK
CLR
GND
VCC
QB
QC
QD
QE
QF
QA
R301A 390
R301B 390
R301C 390
R301D 390
R301E 390
R301F 390
R301G 680
R301H 680
R301J 680
R301K 680
R301L 680
R301M 680
Q301
Q302
Q303
Q304
Q305
Q306
R303 1
C302 .01
C301 100
"AC" DS302
DS301
SEE NOTE 3
"MA" DS303
DS304
DS305
DS306
DS309
DS307
DS308
"MV" DS310
R302A 62
R302B 62
R302C 62
R302D 62
R302H 62
R302F 62
R302E 62
a
b
c
d
e
f
g
dp
Q307
Q308
Q309
Q310
Q311
Q312
Q313
Q314
DS311
DS312
DS313
DS314
DS315
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. FOR MODEL 172 DS306, DS307 AND DS309 ARE NOT USED AND DS308 AND DS310 BECOME DUAL FUNCTION: V/A AND mV/mA RESPECTIVELY.
HIGHEST SCHEMATIC DESIGNATION USED
DS315
Q314
R304
P301
U301
302
CR301
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS
DISPLAY SCHEMATIC
27404D

ZONE	LTR	ECO NO	REVISION	DATE
	A	4996	RELEASED	9-22-75
	B	5293	ADDED Q405, R413 & R414	6-16-76
	C	5451	R401 & R404 WERE 15Ω	11-25-76



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS)
2. (P) DENOTES POWER SUPPLY COMMON.

HIGHEST SCHEMATIC DESIGNATIONS USED

BT403	CR410	F403
J402	Q405	R414
U410		

SCHEMATIC DESIGNATIONS NOT USED

MODEL	NEXT ASSEMBLY	QTY
1728		1

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

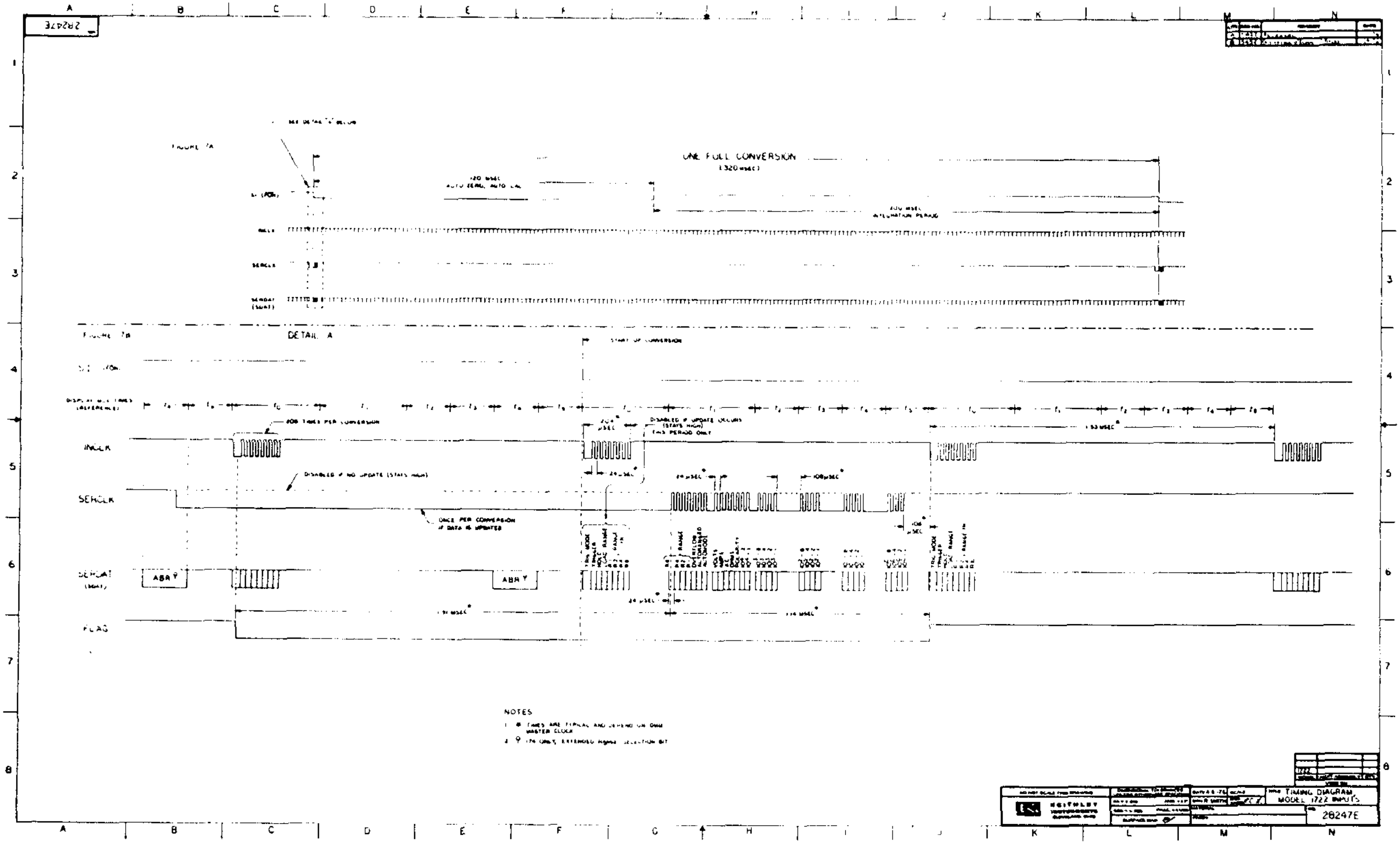
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

DATE 4-2-75 SCALE ~

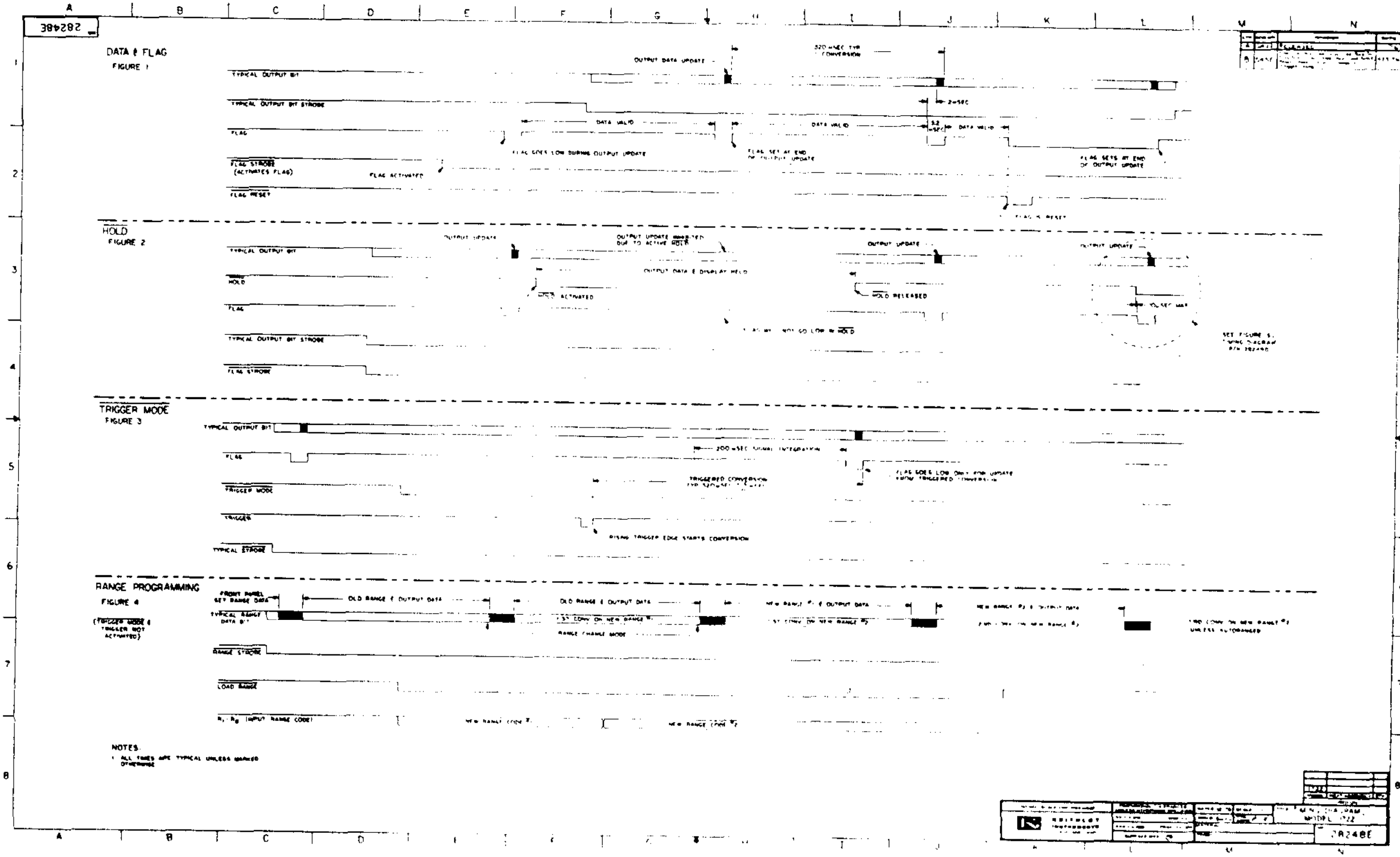
DRN R SMITH

TITLE SCHEMATIC, PC-404, BATTERY PACK

NO. 26758C

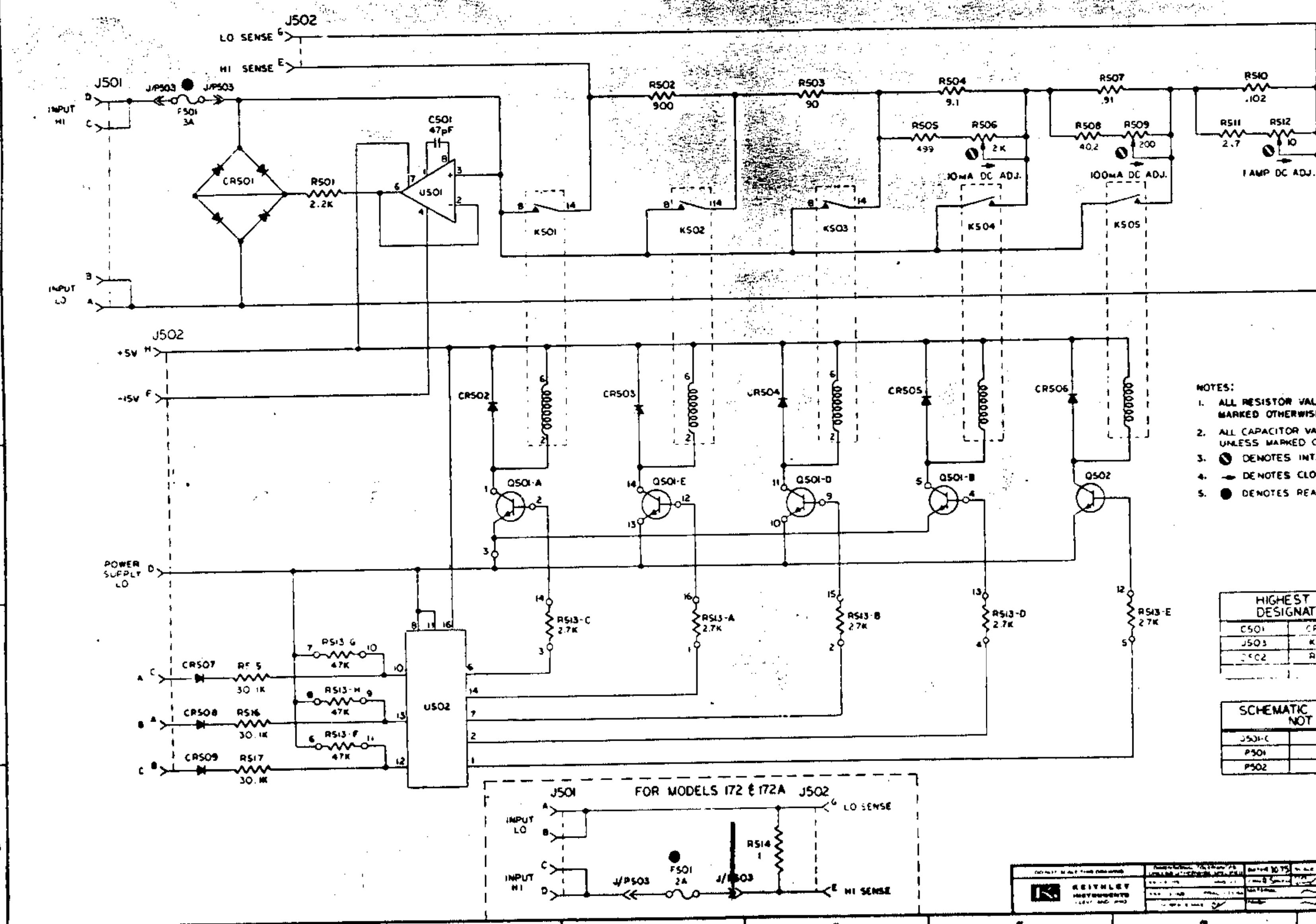


ONE FULL CONVERSION
(320 msec)
120 MSEC
AUTO ZERO, AUTO CAL
200 MSEC
INTEGRATION PERIOD
FIGURE 7A
FIGURE 7B
DETAIL A
START OF CONVERSION
INCLK
SERCLK
SERDAT
(SDAT)
FLAG
208 TIMES PER CONVERSION
DISABLED IF NO UPDATE (STAYS HIGH)
ONCE PER CONVERSION
IF DATA IS UPDATED
DISABLED IF UPDATE OCCURS
(STAYS HIGH)
THIS PERIOD ONLY
ABR
NOTES
1. * TIMES ARE TYPICAL AND DEPEND ON ONE MASTER CLOCK
TIMING DIAGRAM
MODEL 1722 INPUTS
KEITHLEY
28247E



DATA & FLAG
FIGURE 1
TYPICAL OUTPUT BIT
TYPICAL OUTPUT BIT STROBE
FLAG
FLAG STROBE (ACTIVATES FLAG)
FLAG RESET
OUTPUT DATA UPDATE
DATA VALID
FLAG GOES LOW DURING OUTPUT UPDATE
FLAG ACTIVATED
HOLD
FIGURE 2
OUTPUT UPDATE
OUTPUT DATA & DISPLAY HELD
HOLD ACTIVATED
HOLD RELEASED
TRIGGER MODE
FIGURE 3
TRIGGERED CONVERSION
RISING TRIGGER EDGE STARTS CONVERSION
TYPICAL STROBE
TRIGGER
RANGE PROGRAMMING
FIGURE 4
FRONT PANEL SET RANGE DATA
OLD RANGE & OUTPUT DATA
RANGE CHANGE MODE
RANGE STROBE
LOAD RANGE
NOTES:
1. ALL TIMES ARE TYPICAL UNLESS MARKED OTHERWISE

FOR MODELS 173 & 173A



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3. ⊘ DENOTES INTERNAL ADJ.
4. → DENOTES CLOCKWISE ROTATION.
5. ● DENOTES REAR PANEL CONTROL.

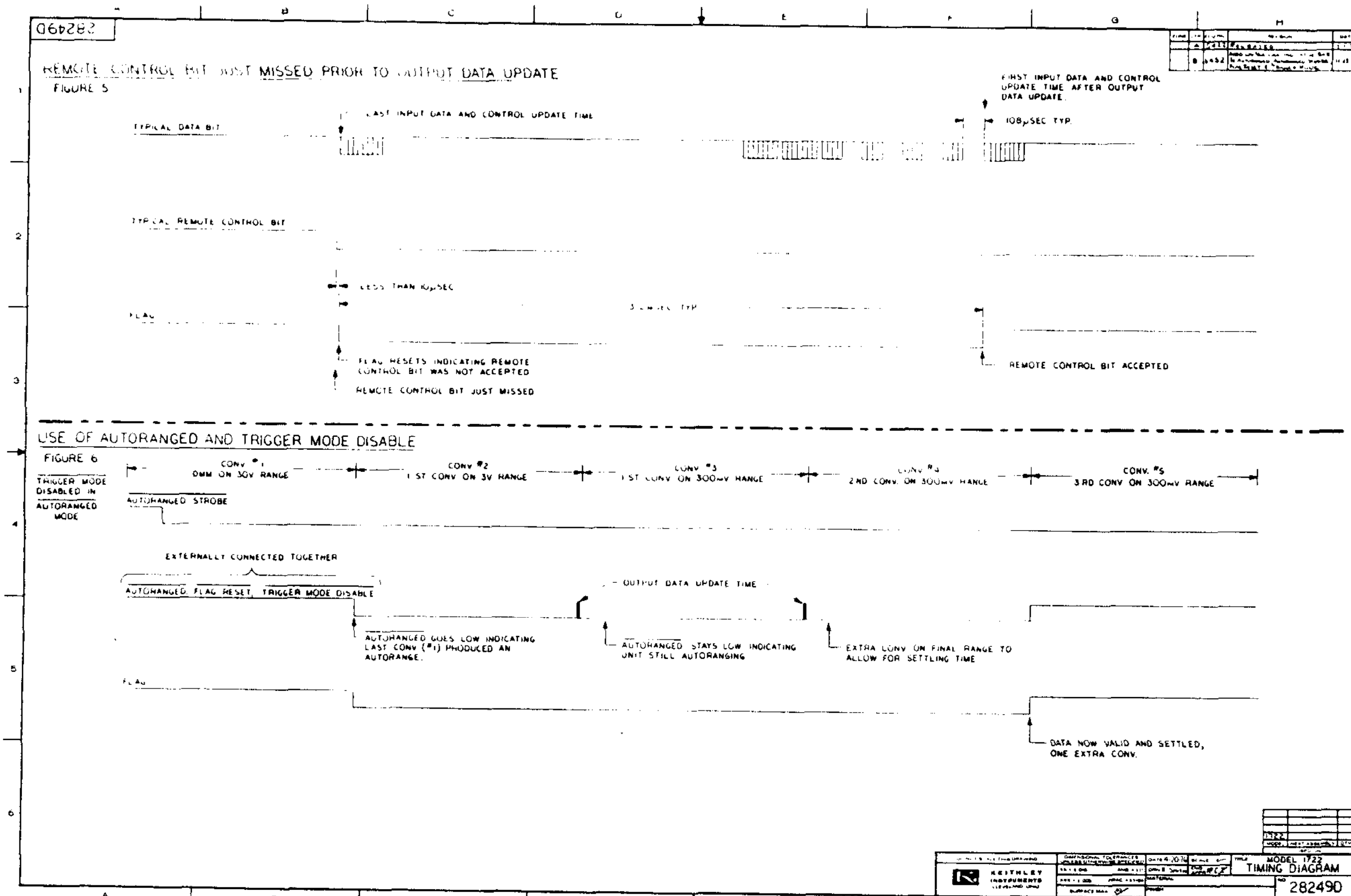
HIGHEST SCHEMATIC DESIGNATIONS USED		
C501	CR509	F501
J503	K505	P503
U502	R517	J502

SCHEMATIC DESIGNATIONS NOT USED		
J501-C		
P501		
P502		

KEITHLEY INSTRUMENTS

SCHEMATIC, PC-406 CURRENT BOARD

27478D


282490
REMOTE CONTROL BIT JUST MISSED PRIOR TO OUTPUT DATA UPDATE
FIGURE 5
TYPICAL DATA BIT
LAST INPUT DATA AND CONTROL UPDATE TIME
FIRST INPUT DATA AND CONTROL UPDATE TIME AFTER OUTPUT DATA UPDATE.
108μSEC TYP.
TYPICAL REMOTE CONTROL BIT
LESS THAN 10μSEC
FLAG
FLAG RESETS INDICATING REMOTE CONTROL BIT WAS NOT ACCEPTED
REMOTE CONTROL BIT JUST MISSED
REMOTE CONTROL BIT ACCEPTED
USE OF AUTORANGED AND TRIGGER MODE DISABLE
FIGURE 6
TRIGGER MODE DISABLED IN AUTORANGED MODE
CONV. #1 OMM ON 30V RANGE
CONV #2 1 ST CONV ON 3V RANGE
CONV #3 1 ST CONV ON 300mV RANGE
CONV #4 2ND CONV. ON 300mV RANGE
CONV. #5 3 RD CONV ON 300mV RANGE
AUTORANGED STROBE
EXTERNALLY CONNECTED TOGETHER
AUTORANGED FLAG RESET TRIGGER MODE DISABLE
OUTPUT DATA UPDATE TIME
AUTORANGED GOES LOW INDICATING LAST CONV (#1) PRODUCED AN AUTORANGE.
AUTORANGED STAYS LOW INDICATING UNIT STILL AUTORANGING
EXTRA CONV ON FINAL RANGE TO ALLOW FOR SETTLING TIME
FLAG
DATA NOW VALID AND SETTLED, ONE EXTRA CONV.
KEITHLEY INSTRUMENTS
MODEL 1722
TIMING DIAGRAM
282490

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"800" SERIES (Schematic 28656E)			
C801	0.1 µF, 200V.	ECI	625B1C104	C-221-.1M
C802	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C803	4.7µF, 20V, ETT.	ITT	TAP4X7E200	C-179-4.7M
C804	150 pF, 1000V, CerD.	CLB	DD-151	C-64-150P
C805	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C806	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C807	220µF, 10V, ETT.	SIE	D220ED10MI	C-78-220M
C808	120 µF, 10V, ETT	C-I	TD5-010127-20	C-180-120M
C809	120 µF, 10V, ETT	C-I	TD5-010127-20	C-180-120M
C810	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C811	33 pF, 1000V, CerD	CLB	DD-330	C-64-33P
C812	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C813	10 µF, 20V, ETT.	C-I	TD2-20-106-20	C-179-10M
C814	2200pF,500V, Mica.	G-I	ROMISFD	C-278-2200P
C815	0.01 µF, 16V, CerD	CLB	UK16-103	C-238-.01M
C816	145pF, 500V, Mica.	G-I	145PF,1%	C-278-145P
C817	1.9-15.7 pF, 250V, Trimmer	EFJ	187-0109-005	C-284-1.9-15.7P
C818	1440pF, 500V, Mica	G-I	1440PF, 1%	C-278-1440P
C819	.25-1.5 pF, Variable	EFJ	273-1-1	C-184-.25-1.5P
C820	.25-1.5 pF, Variable	EFJ	273-1-1	C-184-.25-1.5P
C821	.25-1.5 pF, Variable	EFJ	273-1-1	C-184-.25-1.5P
	"900" SERIES (Schematic 28656E)			
C901	0.01 µF, 50V, MPC.	ECI	625B1A103-J	C-201-.01M
C902	0.1 µF, 10%, 200VDC.	TRW	1-200-10-X363UW	C-269-.1M
C903	33 pF, 1000V, CerD	CLB	DD-330	C-64-33P
C904	0.15 µF, 10%, 200VDC	TRW	15-200-10-X363UW	C-269-.15M
C905	0.15 µF, 10%, 200VDC	TRW	15-200-10-X363UW	C-269-.15M
C906	1000 pF, 500V, Poly	CLB	CPR-1000	C-138-1000P
C907	0.01µF, 1200V	STD	PYW-R-.01	C-286-0.01M
C908	.1 µF, 1000V 20%	STD	M2WF-0.1µF	C-285-.1M
C909	.1 µF, 16VDC	CLB	UK16-104	C-238-.1M
C910	.1 µF, 16VDC	CLB	UK16-104	C-238-.1M

CAPACITORS (C)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E, PC-415)			
C1001	0.01 µF, 500V, CerD	ERI	871-Z5U0-103M	C-22-.01M
C1002	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1003	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1004	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1005	1550 µF, 25V, EAL	RIC	MD16C1550258P	C-272-1550M
C1006	0.01 µF, 500V, CerD	ERI	871-Z5U0-103M	C-22-.01M
C1007	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1008	1000 pF, 1000V, CerD.	ERI	808-000-Z5R0-102K	C-64-1000P
C1009	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1010	39 µF, 15V, ETT	C-I	TD401539610	C-228-39M
C1011	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1012	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1013	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1014	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1015	10 µF, 20V, ETT	ITT	TAP/F010F200	C-179-10M
C1016	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1017	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-.01M
C1018	100 µF, 15V, ETT.	C-I	TD501510710	C-228-100M
	"1100" SERIES (Schematic 28019E, PC-416)			
C1101	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-0.01M
C1102	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-0.01M
C1103	1.2 µF, 20%, 20V.	C-I	TD1-20-125-20	C-179-1.2M
C1104	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-0.01M
C1105	0.01 µF, 16V, CerD.	CLB	UK16-103	C-238-0.01M
C1106	220 pF, 1000V, CerD	CLB	DD-221	C-64-220P
C1107	1000 pF, 1000V, CerD.	ERI	808-000-Z5R0-102K	C-64-1000P

DIODES (CR)

ircuit esig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 28656E)			
CR001	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR002	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R003	Resonator, Ceramic, 669 kHz. . . .	VER	TF-01-669	CR-7
	"100" SERIES (Schematic 28656E)			
CR101	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R102	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
	"200" SERIES (Schematic 28656E)			
CR201	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R202	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR203	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR204	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R205	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R206	Diode, Dual, Low Leakage	INT	ID101	DN-3
CR207	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R208	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R209	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR210	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR211	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R212	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR213	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR214	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
	"400" SERIES (Schematic 26758C)			
R401	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R402	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR403	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR404	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R405	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR406	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR407	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
R408	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR409	Rectifier, 1 A, 800V	MOT	1N4006	RF-38
CR410	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 27478D)			
CR501	Bridge Rectifier, 4 diode, 5A, 50V	EDI	PE05	RF-48
CR502	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR503	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR504	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR505	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR506	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR507	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR508	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR509	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
	"600" SERIES (Schematic 28656E)			
CR601	Bridge Rectifier, 100V, 2 A. . . .	EDI	PD10	RF-36
CR602	Bridge Rectifier, 100V, 2 A. . . .	EDI	PD10	RF-36
	"700" SERIES (Schematic 28656E)			
CR701	Rectifier, 75 mA, 75V	T-I	1N914	RF-28
CR702	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR703	Rectifier, 1A, 800V.	MOT	1N4006	RF-38
CR704	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR705	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
	"800" SERIES (Schematic 28656E)			
CR801	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR802	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR803	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR804	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
	"900" SERIES (Schematic 28656E)			
CR901	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR902	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR903	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR904	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28
CR905	Rectifier, 75 mA, 75V.	T-I	1N914	RF-28

DIODES (CR)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E, PC-415)			
CR1001	Rectifier, 75 mA, 75V	T-I	1N914	RF-28
CR1002	Bridge Rectifier, 100V, 2A. . . .	E-D	PD10	RF-36
	"1100" SERIES (Schematic 28019E)			
CR1101	Rectifier, 75 mA, 75V	T-I	1N914	RF-28

DISPLAYS (DS)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"300" SERIES (Schematic 27404D)			
DS301	Pilot Light, Red, LED.	H-P	B-031075-2501-1	PL-64
DS302	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS303	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS304	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS305	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS306	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS307	Pilot Light, Light-Emitting Diode.	H-P	HP5082-4494	PL-63
DS308	Pilot Light, Light Emitting Diode.	H-P	HP5082-4494	PL-63
DS309	Pilot Light, Light Emitting Diode.	H-P	HP5082-4494	PL-63
DS310	Pilot Light, Light Emitting Diode.	H-P	HP5082-4494	PL-63
DS311	Digital Display, 7-segment	H-P	5082-7650	DD-13
DS312	Digital Display, 7-segment	H-P	5082-7650	DD-13
DS313	Digital Display, 7-segment	H-P	5082-7650	DD-13
DS314	Digital Display, 7-segment	H-P	5082-7650	DD-13
DS315	Digital Display, 7-segment	H-P	5082-7650	DD-13
	"600" SERIES (Schematic 28656E)			
DS601	Pilot Light, Light Emitting Diode.	H-P	HP5082-4494	PL-63

FUSES (F)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C)			
F401	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10
F402	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10
F403	1A, 3AG, 250V, Slo-Blo	FUS	MDL-1AMP	FU-10
	"500" SERIES (Schematic 27478D)			
F501	(Model 173) 3A, 250V, 3AG, Quick. . . .	L-F	312003	FU-2
	(Model 172) 2A, 250V, 3AG, Quick. . . .	L-F	312002	FU-13
	"600" SERIES (Schematic 28656E)			
F601	Slo-Blo, 1/4A, 3AG (117V).	L-F	313.250	FU-17
	Slo-Blo, 1/8A, 3AG (220V).	BUS	MDL-1/8	FU-20

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 28656E)			
J201	Socket, 14-pin DIP	T-I	C931402	SO-70
	"400" SERIES (Schematic 26758C)			
J401	5-pins	MOL	2139-5	CS-287-5
J402	5-pins	MOL	2139-5	CS-287-5
	"500" SERIES (Schematic 27478D)			
J501	5-pin Housing.	BRG	20370	CS-251
J502	8-pin Housing.	BRG	65039C	CS-310
J503	2-pin Housing.(Model 173 only) . .	MOL	03-06-1023	CS-326-2
--	Female Contacts (2 req'd for J503)	MOL	02-06-5103	CS-328

CONNECTORS (J)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"600" SERIES (Schematic 28067D)			
J601	2-pins	MOL	2139-2	CS-275
J602	Not Used	---	---	---
J603	Not Used	---	---	---
J604	3-pin Housing	BRG	65039-034	CS-270
----	Female pin (3 req'd for J604)	BRG	75691-005	CS-236
J605	Not Used	---	---	---
J606	Not Used	---	---	---
J607	Tip Jack, Recessed, Red	EFJ	105-0602-001	BJ-10-2
J608	Tip Jack, Recessed, White	EFJ	105-0610-001	BJ-10-9
J609	Tip Jack, Recessed, Blue	EFJ	105-0601-001	BJ-10-6
	"900" SERIES (Schematic 28656E)			
J901	Not Used	---	---	---
J902	Not Used	---	---	---
J903	Banana Jack, Red	POM	2854	BJ-9-2
J904	Banana Jack, Black	POM	2854	BJ-9-0
J905	Banana Jack, Red	POM	2854	BJ-9-2
J906	Banana Jack, Black	POM	2854	BJ-9-0
	"1000" SERIES (Schematic 27902E)			
J1001	Housing, 5-pins (mates with CS-236)	BERG	20370	CS-251
J1002	Housing, 6-pins	BERG	65043-093	CS-335
J1003	Housing, 2-pins, MINI-PV	BERG	65039-035	CS-266
	"1100" SERIES (Schematic 28019E)			
J1101	Not Used	---	---	---
J1102	Not Used	---	---	---
J1103	Not Used	---	---	---
J1104	Card-edge connector	MOL	09-52-3102	CS-332-10
J1105	Card-edge connector	MOL	09-52-3122	CS-332-12

RELAYS (K)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 27478D)			
K501	Relay, Reed, 0.5A, Form A.	WAB	1170-3-1	RL-44
K502	Relay, Reed, 0.5A, Form A.	WAB	1170-3-1	RL-44
K503	Relay, Reed, 0.5A, Form A.	WAB	1170-3-1	RL-44
K504	Relay, Reed, 1.5A, Form A.	QTN	H5A1M-S20	RL-50
K505	Relay, Reed, 3A.	WAB	1170-2-1	RL-49
	"800" & "900" SERIES (Schematic 27903E)			
K801	Relay, reed, form 1 A, 20V	WAB	1170-5-2	RL-53
K901	Relay.	P&B	R10-E3738-1	RL-51

CONNECTORS (P)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"100" SERIES (Schematic 28656E)			
P101	3-pin Housing.	BRG	65507-136	CS-339-3
	"300" SERIES (Schematic 27404D)			
P301	Cable Assembly	K-1	--	27961A
	"500" SERIES (Schematic 28656E)			
P501	Not Used	--	--	--
P502	Not Used	--	--	--
P503	Connector (Model 172 only)	--	--	--
	"600" SERIES (Schematic 28656E)			
P601	Receptacle, 5-pin.	MOL	A-2391-5A	CS-288-5
P602	Receptacle, 2-pin.	MOL	A-2391-2A	CS-288-2
P603	Receptacle, 4-pin.	BRG	65507-136	CS-339-4
P604	Receptacle, 3-pin.	BRG	65507-136	CS-339-3
P605	Receptacle, 2-pin.	BRG	65507-136	CS-339-2
P606	Receptacle, 5-pin.	MOL	A-2391-5A	CS-288-5
P607	Not Used	--	--	--
P608	Not Used	--	--	--
P609	Not Used	--	--	--
P610	Line Cord.	BLD	17237	CO-9

CONNECTORS (P)

Circuit esig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"900" SERIES (Schematic 28656E)			
901	Connector 8-pin	BRG	65507-136	CS-339-8
P902	Connector 4-pin	BRG	65507-136	CS-339-4
	"1000" SERIES (Schematic 27902E, PC-415)			
1001	Not Used.	---	---	---
r1002	Not Used.	---	---	---
P1003	Not Used.	---	---	---
'1004	Connector, 10 pins.	MOL	09-67-1104	CS-331-10
.'1005	Connector, 12 pins.	MOL	09-67-1124	CS-331-12
P1006	Card-edge, 40 pins (part of Model 1727. . .	MMM	3464-0000	CS-294-3
	"1100" SERIES (Schematic 28019E)			
'1101	Card-edge, 26-pin (part of Model 1727). . .	MMM	3462-0000	CS-294-1

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 28656E)			
Q001	Transistor, Dual, Monolithic PNP.	A-D	AD820	TG-121
Q002	NPN, Case TO-106.	F-I	2N5134	TG-65
Q003	NPN, Case TO-106.	F-I	2N5134	TG-65
	"100" SERIES (Schematic 28656E)			
Q101	PNP Silicon, TO-92 Case	MOT	2N3905	TG-53
Q102	Differential Amp.	INT	IT122	TG-73
Q103	NPN, Case TO-106 (*Selected TG-39).	F-I	2N3565*	28234A*
Q104	P-Chan MOS FET.	INT	3N163	TG-126
Q105	Differential AMP.	INT	IT122	TG-73
Q106	Dual FET.	SIL	E411	TG-118
Q107	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88
Q108	N-Chan, J-FET.	INT	ITE4392	TG-77
Q109	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88
Q110	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88
Q111	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88
Q112	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88
Q113	N-Chan, J-FET, Case TO-18	INT	ITS3538	TG-88

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 28656E)			
Q201	N-Chan, J-FET, Case To-92.	NAT	PN4392	TG-129
Q202	N-Chan, J-FET, Case TO-18.	INT	ITS3538	TG-88
Q203	N-Chan, J-FET, Case TO-92.	NAT	PN4393	TG-130
Q204	N-Chan, J-FET	INT	ITE4392	TG-77
Q205	N-Chan, J-FET, Case TO-92.	NAT	PN4392	TG-130
Q206	Transistor, NPN, Case TO-106 . . .	F-I	2N3565	TG-39
Q207	PNP, TO-92 Case	MOT	2N3905	TG-53
Q208	PNP, Case to TO-92	MOT	ITS3538	TG-53
Q209	N-Chan, J-FET, Case TO-92	NAT	PN4392	TG-128
Q210	N-Chan, J-FET, Case TO-92	NAT	PN4392	TG-128
Q211	N-Chan, J-FET, Case TO-92	NAT	PN4392	TG-128
Q212	Transistor, NPN, Case TO-106 . . .	F-I	2N3565	TG-39
Q213	Transistor, NPN, Case TO-106 . . .	INT	2N3565	28234A *
Q214	Transistor, NPN, Case TO-106 . . .	INT	2N3565	28234A *
Q215	Transistor, NPN, Case TO-106 . . .	INT	2N3565	28234A *
Q216	PNP, TO-92, Case TO-106.	MOT	2N3905	TG-53

*Selected TG-39

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"300" SERIES (Schematic 27404D)			
Q301	PNP, Case TO-106	F-I	2N4355	TG-90
Q302	PNP, Case TO-106	F-I	2N4355	TG-90
Q303	PNP, Case TO-106	F-I	2N4355	TG-90
Q304	PNP, Case TO-106	F-I	2N4355	TG-90
Q305	PNP, Case TO-106	F-I	2N4355	TG-90
Q306	PNP, Case TO-106	F-I	2N4355	TG-90
Q307	PNP, Case R-110.	F-I	S17638	TG-33
Q308	PNP, Case R-110.	F-I	S17638	TG-33
Q309	PNP, Case R-110.	F-I	S17638	TG-33
Q310	PNP, Case R-110.	F-I	S17638	TG-33
Q311	PNP, Case R-110.	F-I	S17638	TG-33
Q312	PNP, Case R-110.	F-I	S17638	TG-33
Q313	PNP, Case R-110.	F-I	S17638	TG-33
Q314	PNP, Case R-110.	F-I	S17638	TG-33

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"400" SERIES (Schematic 26758C)			
Q401	PNP, Case TO-5	RCA	2N4032	TG-92
Q402	NPN, Case TO-39.	MOT	2N3300S	TG-117
Q403	PNP, Case TO-5	RCA	2N4032	TG-92
Q404	NPN, Case TO-106	F-I	2N3565	TG-39
Q405	PNP, Case TO-92	MOT	2N5087	TG-61
	"500" SERIES (Schematic 27478D)			
Q501	Transistor Array, 14-pin DIP . . .	RCA	CA3086	IC-53
	"700" SERIES (Schematic 28656E)			
Q701	NPN, Case TO-106	F-I	2N3565	TG-39
Q702	N-Chan, J-FET.	INT	ITE4392	TG-77
Q703	N-Chan, J-FET, Case TO-18.	INT	ITS3538	TG-88
Q704	PNP Silicon, Case TO-92.	MOT	MPS404A	TG-99
Q705	NPN, Case TO-106	F-I	2N3565	TG-39
Q706	Silicon, PNP TO-92Case	MOT	2N5087	TG-61
Q707	N-Chan, J-FET, Case TO-18.	INT	ITS3538	TG-88
Q708	NPN, Case TO-106 (*Selected TG-39)	F-I	2N3565*	28234A*
Q709	NPN, Case TO-106 (*Selected TG-39)	F-I	2N3565*	28234A*
Q710	FET, Case TO-18 (*Selected TG-88)	INT	ITS3538*	28250A*
	"800" SERIES (Schematic 28656E)			
Q801	FET, Case TO-72	SIG	2D210	TG-119
Q802	PNP Silicon, TO-92 Case	MOT	2N3905	TG-53
Q803	Dual FET.	SIL	E411	TG-118
Q804	FET, Case TO-18 (*Selected TG-88)	INT	ITS3538*	28229A*
Q805	Transistor Array, 14-pin DIP. . .	RCA	CA3086**	28228A**

**Selected IC-53

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"900" SERIES (Schematic 28656E)			
Q901	N-Chan, J-FET, Case TO-18.	INT	ITS3538	TG-88
Q902	NPN, Case R-110.	F-I	2N3643	TG-123
Q903	PNP Silicon, TO-92 Case.	MOT	2N3905	TG-53

TRANSISTORS (Q)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1000" SERIES (Schematic 27902E, PC-415)			
Q1001	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1002	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1003	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1004	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1005	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1006	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1007	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1008	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1009	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1010	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1011	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1012	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1013	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1014	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1015	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1016	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1017	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1018	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1019	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1020	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1021	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1022	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1023	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1024	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1025	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1026	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1027	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1028	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1029	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1030	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1031	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1032	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1033	NPN, Case TO-106.	F-1	2N5134	TG-65
Q1034	PNP, Case R-110	F-1	S17638	TG-33
Q1035	PNP, Case R-110	F-1	S17638	TG-33
Q1036	PNP, Case R-110	F-1	S17638	TG-33
Q1037	PNP, Case R-110	F-1	S17638	TG-33
	"1100" SERIES (Schematic 28019E)			
Q1101	NPN, Case TO-106.	F-1	2N5134	TG-65

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 28656E)			
R001	6.04 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-6.04K	R-88-6.04K
R002	Thick Film Resistor Network. . . .	K-1	--	TF-47
R003	10 kΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-10K
R004	18 kΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-18K
R005	6.8kΩ, 10%, 1/4W, Comp	A-B	CB-682-10%	R-76-6.8K
R006	5.49kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-5.49K	R-88-5.49K
R007	7.68kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-7.68K	R-88-7.68K
R008	10MΩ, 10% 1/4W, Comp	A-B	CB-106-10%	R-76-10M
R009	100Ω, 1%, 1/8W, MtF	IRC	CEA-TO-100	R-88-100
R010	1.5KΩ, 1%, 1/8W, MtF	IRC	CEA-TO-1.5K	R-88-1.5K
R011	4.22KΩ, 1%, 1/8W, MtF	IRC	CEA-TO-4.22K	R-88-4.22K
R012	1.15KΩ, 1%, 1/8W, MtF	IRC	CEA-TO-1.15K	R-88-1.15K
R013	49.9K, 1%, 1/8W, MtF	IRC	CEA-TO-49.9K	R-88-49.9K
R014	15Ω, 10%, 1/4W, Comp	A-B	CB-150-10%	R-16-15
	"100" SERIES (Schematic 28656E)			
R101	280 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-280	R-88-280
R102	280 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-280	R-88-280
R103	1 kΩ, Potentiometer, 0.5W.	BEC	72PMR	RP-97-1K
R104	6.336 kΩ, 0.1%, 1/8W, MtF.	DLE	MFF-1/8-6.336K	R-168-6.336K
R105	150 kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-150K	R-88-150K
R106	470 Ω, 10%, 1/4W, Comp	A-B	CB-121-10%	R-76-470
R107	470 Ω, 10%, 1/4W, Comp	A-B	CB-121-10%	R-76-470
R108	200 kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-200K	R-88-200K
R109	Thick Film Resistor Network. . . .	K-1	--	TF-49
R110	Thick Film Resistor Network. . . .	K-1	--	TF-46
R111	22kΩ, 10%, 1/4W, Comp	A-B	CB-223-10%	R-76-22K
R112	43kΩ, 5%, 1/4W, Comp	MEP	CR-25-43K	R-248-43K
R113	22KΩ, 10%, 1/4W, Comp	A-B	CB-223-10%	R-76-22K
R114	22KΩ, 10%, 1/4W, Comp	A-B	CB-223-10%	R-76-22K
	"200" SERIES (Schematic 28656E)			
R201	5 kΩ, 0.5W, Var.	BEC	72PMR-5K	RP-97-5K
R202	374 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-374	R-88-374
R203	7.50 kΩ, 0.1%, 1/8W.	DLE	MFF-1/8-7.50K	R-168-7.50K
R204	7.50 kΩ, 0.8%, 1/8W.	DLE	MFF-1/8-7.50K	R-168-7.50K
R205	28.0 kΩ, 0.5%, 1/8W.	DLE	MFF-1/8-28.0K	R-246-28.0K
R206	Part of 28040B			
R207	Part of 28040B			
R208	20 kΩ, Potentiometer, 0.5W	BEC	72PMR-20K	RP-97-20K
R209	500 Ω, Potentiometer, 0.5W	BEC	72PMR-500	RP-97-500
R210	Thin Film Resistor Network	K-1	--	TF-56
R211	23.2 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-23.2K	R-88-23.2K
R212	332 kΩ, 0.1%, 1/8W, MtF.	DLE	MFF-1/8-332K	R-168-332K

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Cont'd)			
R213	100 kΩ, 5%, 0.5W	BRN	3299W-11-104-5%	RP-114-100K
R214	Thick Film Resistor Network	K-I	--	TF-51
R215	Thick Film Resistor Network	K-I	--	TF-45
R216	909 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-909	R-88-909
R217	10 kΩ, Potentiometer, 0.5W	BEC	72PMR	RP-97-10K
R218	Thick Film Resistor Network	K-I	--	TF-50
R219	1.8 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-1.8K	R-88-1.8K
R220	10 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-10K	R-88-10K
R221	200 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-200	R-88-200
R222	200 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-200K	R-88-200K
R223	39 kΩ, 10%, 1/4W, Comp	A-B	CB-393-10%	R-76-39K
R224	Thick Film Resistor Network	K-I	--	TF-48
R225	10 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-10K	R-88-10K
R226	210kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-210K	R-88-210K
R227	22 Ω, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-22K
R228	22 Ω, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-22K
R229	15 kΩ, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-15K
R230	Thick Film Resistor Network	K-1	--	TF-60
R231	8.2 kΩ, 10%, 1/4W, Comp	A-B	CB-822-10%	R-76-8.2K
	"300" SERIES (Schematic 27404D)			
R301	Thick Film Resistor Network	K-I	--	TF-42
R302	Thick Film Resistor Network	BEC	898-3-R62	TF-43
R303	1 Ω, 1%, 1/2W	IRC	DCC-1Ω	R-12-1
R304	2.2Ω, 5%, 1/4W	DLE	SBB-2.2Ω	R-248-2.2
	"400" SERIES (Schematic 26758C)			
R401	13.7Ω, 1%, 1/8W, MtF	IRC	CEA-TO-13.7Ω	R-88-13.7
R402	12 kΩ, 10%, 1/2W, Comp	A-B	EB-123-10%	R-1-12K
R403	12 kΩ, 10%, 1/2W, Comp	A-B	EB-123-10%	R-1-12K
R404	13.7Ω, 1%, 1/8W, MtF	IRC	CEA-TO-13.7Ω	R-88-13.7
R405	3.3 Ω, 10%, 1/2W, Comp	A-B	EB-3R3-10%	R-1-3.3
R406	1.5 kΩ, 10%, 1/2W, Comp.	A-B	EB-152-10%	R-1-1.5K
R407	71.5 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-71.5K	R-88-71.5K
R408	100 kΩ, 10%, 1/4W, Comp.	A-B	CB-104-10%	R-76-100K
R409	2.2 kΩ, 10%, 1/4W, Comp.	A-B	CB-222-10%	R-76-2.2K
R410	76.8 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-76.8K	R-88-76.8K
R411	499 kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-499K	R-88-499K
R412	100 kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-100K	R-88-100K
R413	110 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-110K	R-88-110K
R414	499 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-499K	R-88-499K

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"500" SERIES (Schematic 28067D)			
R501	Not Used			
R502	900 Ω, 0.05%, 1/2W	IRC	MAR6-900Ω	R-236-900
R503	90 Ω, 0.05%, 1/8W	IRC	MAR6-90Ω	R-236-90
R504	9.1 Ω, 0.5%, 1/2W	TEP	TS.5S-9.1Ω	R-237-9.1
R505	499 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-499	R-88-499
R506	10 kΩ, 0.5W, Var	BEC	72PMR-10K	RP-97-10K
R507	0.91 Ω, 0.5%, 5W	TEP	TS5-0.91	R-238-.91
R508	40.2 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-40.2	R-88-40.2
R509	1 kΩ, 0.5W, Var	BEC	72PMR-1K	RP-97-1K
R510	0.102 Ω, 0.5%, 10W	TEP	TS10-0.102Ω	R-239-.102
R511	2.7 Ω, 10%, 1/4W, Comp	A-B	CB-2R7-10%	R-76-2.7
R512	10 Ω, 0.5W, Var	BEC	72PMR-10	RP-97-10
R513	Thick Film Resistor Network	K-1	--	TF-44
R514	1 Ω, 0.1%, 10W, WW	TEP	TS-10W-1Ω	R-221-1
	R502-R513 used on Model 173 only. R514 used on Model 172 only.			
R515	30.1KΩ, 1%, 1/8W, MtF	IRC	CEA-30.1K-1%	R-88-30.1K
R516	30.1KΩ, 1%, 1/8W, MtF	IRC	CEA-30.1K-1%	R-88-30.1K
R517	30.1KΩ, 1%, 1/8W, MtF	IRC	CEA-30.1K-1%	R-88-30.1K
	"600" SERIES (Schematic 28656E)			
R601	120 Ω, 5%, 1W, Comp	A-B	GB-121-5%	R-102-120
R602	120 Ω, 5%, 1W, Comp	A-B	GB-121-5%	R-102-120
R603	15Ω, 5%, 5W, WW	OHM	4565	R-257-15
R604	680 Ω, 10%, 1/2W, Comp	A-B	EB-681-10%	R-1-680
R605	100 Ω, 10%, 1W, Comp	A-B	GB-101-10%	R-2-100
R606	270Ω, 10%, 1/2W, Comp	A-B	EB-271-10%	R-1-270
R607	6.65 kΩ 1%, 1/8W, MtF	IRC	CEA-TO-6.65K	R-88-6.65K
R608	4.9 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-4.99K	R-88-4.99K
R609	10 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-10K	R-88-10K
R610	680 Ω, 10%, 1/2W, Comp	A-B	EB-681-10%	R-1-680
R611	10 kΩ, 10%, 1/4W, Comp	A-B	CB-103-10%	R-76-10K
R612	10Ω, 10%, 1/4W, Comp	A-B	CB-100-10%	R-76-10

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"700" SERIES (Schematic 28656E)			
R701	Thick Film Resistor Network. . . .	KI	-	TF-61
R702	Thick Film Resistor Network. . . .	KI	-	TF-62
R703	62Ω,,10%, 1/2W, Comp	A-B	EB-620-10%	R-1-62
R704	5 kΩ, 0.5W, Var.	BEC	72PMR-5K	RP-97-5K
R705	500 kΩ, Potentiometer, 0.5W. . . .	BEC	72PMR-500K	RP-97-500K
R706	335.3 kΩ, 0.1%, 1/8W	TRW	MAR-6-T10-0.1%	R-241-335.3K
R707	1 kΩ, Potentiometer, 0.5W.	BEC	72PMR-1K	RP-97-1K
R708	3.280 kΩ, 0.1%, 1/8W, MtF.	IRC	MAR6	R-240-3.280K
R709	50 Ω, Potentiometer, 0.5W.	BEC	72PMR-50	RP-97-50
R710	33.2 MΩ, 0.25%, 2W	CAD	MG721	R-242-33.2M
	"800" SERIES (Schematic 28656E)			
R801	150 kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-150K	R-88-150K
R802	2.196 kΩ, 0.1%, 1/8W, MtF.	IRC	MAR-6	R-241-2.196K
R803	50 Ω, Potentiometer, 0.5W.	BEC	72PMR-50	RP-97-50
R804	10 kΩ, 10%, 1/4W, Comp	A-B	CB-103-10%	R-76-10K
R805	68.1 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-68.1K	R-88-68.1K
R806	68.1 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-68.1K	R-88-68.1K
R807	500Ω, 0.1%, 1/8W, MtF.	IRC	MAR-6	R-241-500
R808	10MΩ, 10%, 1/4W, Comp.	A-B	CB-106-10%	R-76-10M
R809	100 kΩ, Potentiometer, 0.5W. . . .	BEC	72PMR-100K	RP-97-100K
R810	24.3 kΩ, 0.1%, 1/8W, MtF.	IRC	CEA-TO-24.3	R-88-24.3K
R811	15.8 KΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-15.8K	R-88-15.8K
R812	500 Ω, 1%, 1/8W, MtF.	IRC	MAR-6	R-241-500
R813	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
R814	2MΩ] Part of matched set, part no: R-243			
R815	19.95kΩ] Part of matched set, part no: R-243			
R816	500 Ω, Potentiometer, 0.5W	BEC	72PMR-500	RP-97-500
R817	100 Ω, Potentiometer, 0.5W.	BEC	72PMR-100	RP-97-100
R818	2MΩ,] Part of matched set, part no: R-243			
R819	2.15kΩ] Part of matched set, part no: R-243			
R820	1 MΩ, 10%, 1/4W, Comp.	A-B	CB-105-10%	R-76-1M
	"900" SERIES (Schematic 28656E)			
R901	100 Ω, Potentiometer, 0.5W	BEC	72PMR-100	RP-97-100
R902	2.7 Ω, 10%, 1/4W, Comp	A-B	CB-2R7-10%	R-76-2.7
R903	1 MΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-1M	R-88-1M
R904	200 kΩ, Potentiometer, 0.5W. . . .	BEC	72PMR-200K	RP-97-200K
R905	2.7 Ω, 10%, 1/4W, Comp	A-B	CB-2R7-10%	R-76-2.7
R906	1 MΩ, 10%, 1/4W, Comp.	A-B	CB-105-10%	R-76-1M
R907	NOT USED			
R908	NOT USED			
R909	10.91KΩ Part of matched set R-259			
R910	99.75KΩ Part of matched set R-259			

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"900" SERIES (Cont'd)			
R911	500 Ω, Potentiometer, 0.5W	BEC	72PMR-500	RP-97-500
R912	1 MΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-1M	R-88-1M
R913	200 kΩ, Potentiometer. 0.5W. . . .	BEC	72PMR-200K	RP-97-200K
R914	NOT USED			
R915	9.75MΩ Part of matched set R-259			
R916	1Ω, 1%, 1/2W	IRC	DCC-1-1%	R-12-1
R917	133kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-133K	R-88-133K
R918	49.9 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-49.9K	R-88-49.9K
R919	49.9 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-49.9K	R-88-49.9K
R920	470 Ω, 10%, 1/4W, Comp	A-B	CB-121-10%	R-76-470
R921	10kΩ, 1%, 1/8W, MtF.	IRC	CEA-TO-10K	R-88-10K
R922	133kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-133K	R-88-133K
R923	27kΩ, 10%, 1/2W, Comp.	A-B	EB-273-10%	R-1-27K
R924	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
R925	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
R926	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
R927	1 kΩ, 10%, 1/4W, Comp.	A-B	CB-102-10%	R-76-1K
R928	150kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-150K	R-88-150K
R929	150kΩ, 1%, 8W, ...	CAD	MS-281, 150K	R-247-150K
R930	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
R931	3.3kΩ, 10%, 1/4W, Comp	A-B	CB-332-10%	R-76-3.3K
	"1000" SERIES (Schematic 27902E)			
R1001	Resistor Network, Thick Film , . .	K-1	-	TF-53
R1002	Resistor Network, Thick Film . . .	K-1	-	TF-53
R1003	Resistor Network, Thick Film . . .	K-1	-	TF-53
R1004	Resistor Network, Thick Film . . .	K-1	-	TF-53
R1005	Resistor Network, Thick Film . . .	K-1	-	TF-53
R1006	1 kΩ, 10%, 1/4W, Comp.	A-B	CB-102-10%	R-76-1K
R1007	32.4 kΩ, 1%, 1/8W, MtF	IRC	CEA-TO-32.4K	R-88-32.4K
R1008	1 MΩ, 10%, 1/4W, Comp.	A-B	CB-105-10%	R-76-1M
R1009	3.9 kΩ, 10%, 1/4W, Comp.	A-B	CB-392-10%	R-76-3.9K
R1010	3.9 kΩ, 10%, 1/4W, Comp.	A-B	CB-392-10%	R-76-3.9K
R1011	154 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-154	R-88-154
R1012	3.9 kΩ, 10%, 1/4W, Comp.	A-B	CB-392-10%	R-76-3.9K
R1013	154 Ω, 1%, 1/8W, Mtf	IRC	CEA-TO-154	R-88-154
R1014	154 Ω, 1%, 1/8W, MtF..	IRC	CEA-TO-154	R-88-154
R1015	154 Ω, 1%, 1/8W, MtF	IRC	CEA-TO-154	R-88-154
R1016	10 Ω, 10%, 1/4W, Comp.	A-B	CB-100-10%	R-76-10

RESISTORS (R)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 28019E)			
R1101	11 kΩ, 1%, 250V, 1/8W	IRC	CEA-TO-11KΩ	R-88-11K
R1102	Resistor Newwork, Thick Film.	K-I	-	TF-54
R1103	Resistor Network, Thick Film.	K-I	-	TF-54
R1104	Resistor Network, Thick Film.	K-I	-	TF-54
R1105	Resistor Network, Thick Film.	K-I	-	TF-54
R1106	6.5 kΩ, 1%, 1/8W.	IRC	CEA-TO-6.5KΩ	R-88-6.5K
R1107	10 kΩ, 1%, 1/8W	IRC	CEA-TO-10KΩ	R-88-10K

SWITCHES (S)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"600" SERIES (Schematic 28656E)			
S601	Switch, Slide, DPDT	C-W	GF326-0006	SW-397
	"900" SERIES (Schematic 27903E)			
S901	(Modified SW-393)	K-I	-	28004B

TRANSFORMERS (T)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"600" SERIES (Schematic 28656E)			
T601	Power Transformer	K-I	-	TR-163
	"1000" SERIES (Schematic 27902E)			
T1001	Transformer	K-I	-	TR-164

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"000" SERIES (Schematic 28656E)			
U001	Transistor array, 14-pin DIP . . .	RCA	CA3086	IC-53
U002	Flip-Flop, 14-pin DIP.	F-I	9LS74	IC-144
U003	Flip-Flop, 14-pin DIP.	F-I	9LS74	IC-144
U004	Hex Inverter, 16-pin DIP . . .	RCA	CD4049AE	IC-106
U005	Timing Logic, 8-pin DIP.	SIG	NE555V	IC-71
	"100" SERIES (Schematic 28656E)			
U101	Linear Op-Amp, 8-pin DIP	INT	LM308PA	IC-99
U102	Large-Scale Integrated Circuit . .	K-I	--	LSI-5
U103	Large-Scale Integrated Circuit . .	K-I	--	LSI-4
	"200" SERIES (Schematic 28656E)			
U201	Transistor array, 14-pin DIP . . .	RCA	CA3086 *	28090A*
U202	Operational Amplifier, 8-pin, TO-5 Case.	NAT	LH0042CH	IC-132

*Selected IC-53

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"300" SERIES (Schematic 27404D)			
U301	8-Bit Parallel-Out Serial Shift Register, 14-pin DIP	T-I	SN74LS164	IC-127
	"400" SERIES (Schematic 26758C)			
U401	Operational Amplifier, 8-pin DIP .	F-I	U9T7741393	IC-42
	"500" SERIES (Schematic 27478D)			
U501	Operational Amplifier, 8-pin DIP .	INT	LM308PA	IC-99
U502	COS/MOS BCD-TO-DECIMAL decoder, 16-pin DIP	RCA	CD4028AE	IC-135
	"700" SERIES (Schematic 28656E)			
U701	Operational Amplifier, 8-pin DIP .	NAT	LM308PA	IC-99
U702	Op-Amp, 8-pin, TO-5 Case	NAT	LH0042CH	IC-132

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"800" SERIES (Schematic 28656E)			
U801	Operational Amplifier, 8-pin DIP.	NAT	LM301AN	IC-24
U802	Operational Amplifier, 8-pin DIP.	NAT	LM301AN	IC-24
U803	Analog Amplifier, 8-pin DIP	NAT	LF356H	IC-152
	"900" SERIES (Schematic 28656E)			
U901	Linear Op-Amp, 8-pin DIP.	NAT	LM308PA	IC-99
	"1000" SERIES (Schematic 27902E)			
U1001	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1002	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1003	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1004	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1005	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1006	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1007	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1008	COS/MOS Dual 4-Stage Static Shift Register.	RCA	CD4015AE	IC-136
U1009	COS/MOS Dual 4-Stage Static Shift Register.	RCA	CD4015AE	IC-136
U1010	COS/MOS Dual 4-Stage Static Shift Register.	RCA	CD4015AE	IC-136
U1011	COS/MOS Dual 4-Stage Static Shift Register.	RCA	CD4081BE	IC-136
U1012	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1013	Quad 2-Input AND, 14-pin DIP.	RCA	CD4081BE	IC-138
U1014	Quad 2-Input NOR, 14-pin DIP.	RCA	CD4001AE	IC-108
U1015	Dual D-Type Flip-Flop, 14-pin DIP	RCA	CD4013AE	IC-103
U1016	COS/MOS Hex Inverter, 14-pin DIP.	RCA	CD4069BE	IC-139
U1017	Timing Logic, 8-pin DIP	SIG	NE555V	IC-71
U1018	Optically-coupled Isolator, 8-pin DIP . . .	H-P	HP5082-4351	IC-142
U1019	Optically-coupled Isolator, 8-pin DIP . . .	H-P	HP5082-4351	IC-142
U1020	Optically-coupled Isolator, 8-pin DIP . . .	H-P	HP5082-4351	IC-142
U1021	Optically-coupled Isolator, 8-pin DIP . . .	H-P	HP5082-4351	IC-142

INTEGRATED CIRCUITS (U)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"1100" SERIES (Schematic 28019E)			
U1101	Hex Inverters, Open Collector Output.. . .	TEXAS	SN74LS05N	IC-141
U1102	Hex Inverters, Open Collector Output.. . .	TEXAS	SN74LS05N	IC-141
U1103	Hex Inverters, Open Collector Output.. . .	TEXAS	SN74LS05N	IC-141
U1104	Positive-NAND Gates and Inverters/ Totem-pole outputs	TEXAS	SN74LS14N	IC-137
U1105	Hex Inverters, Open Collector Output . . .	TEXAS	SN74LS05N	IC-141
U1106	Dual D-Type Flip-Flop, 14-pin DIP.	RCA	CD4013AE	IC-103
U1107	Quad 2-Input NOR, 14-pin DIP	RCA	CD4001AE	IC-108
U1108	COS/MOS 8-Stage Static Shift Register	RCA	CD4021AE	IC-130
U1109	Quad 2-Input AND, 14-pin DIP	RCA	CD4081BE	IC-138
U1110	COS/MOS Dual 4 Input NAND Gates.	RCA	CD4012AE	IC-140
U1111	Six COS/MOS Hex Inverter	RCA	CD4069BE	IC-139

VOLTAGE REGULATORS (VR)

Circuit Desig.	Description	Mfr. Code	MFR. Desig.	Keithley Part No.
	"100" SERIES (Schematic 28656E)			
VR101	Zener, 9.1V, 400mW	DIC	1N960B	DZ-55
VR102	Zener, 6.2V, 1/4W.	DIC	1N827A	DZ-48
	"200" SERIES (Schematic 28656E)			
VR201	Zener, 6.2V, 1/4W - Part of matched set 28040B			
VR202	Zener, 9V - Part of matched set 28040B			
VR203	Zener, 12V, 400mV	DIC	1N963B	DZ-54
	"600" SERIES (Schematic 28656E)			
VR601	Voltage Regulator, +8V, Case TO-92	NAT	LM340LAZ-8.0	IC-164
VR602	Regulator, 5v, Case TO-220 (IC-93).	F-I	UGH7805393	28515A
VR603	Regulator, ±15V, TO-66 Case	RAY	RC4195TK	IC-128
	"800" SERIES (Schematic 28656E)			
VR801	Zener, 12V, 400mW	DIC	1N963B	DZ-54

JUMPERS (W)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
	"200" SERIES (Schematic 28656E)			
W201		K-1	---	J-3
	"500" SERIES (Schematic 28656E)			
W501		K-1		J-3
	"600" SERIES (SCHEMATIC 28656E)			
W601		K-1		J-3
	"800" SERIES (SCHEMATIC 28656E)			
W801		K-1	--	J-3
	"900" SERIES (Schematic 28656E)			
W901	(Used only on Model 173)	K-1	--	WIRE

MISCELLANEOUS

DESCRIPTION	KEITHLEY PART NO.
Top Cover (less metalcal)	27979C
. . Metalcal for top cover	MC-236
Bottom Cover (less metalcals)	25727E
. . Metalcal, operating instructions	MC-239
. . Metalcal, rear panel	MC-235
Handle (less insert)	25729D
. . Insert (2 req'd)	26090A
Spacer (4 req'd)	25762B
Rubber foot (4 req'd)	FE-10
Front Panel - Model 172	28029A
Front Panel - Model 173	27958A
"O" Ring (Used to hold display board)	GA-18

TABLE 7-2
COMPONENT DESIGNATIONS FOR PC-407 (MODEL 173)
(See Figure 43.)

Circuit Desig.	Location Code
C001	G-27
C002	G-27
C003	K-26
C004	M-26
C005	M-25
C006	S-29
C007	U-29
C008	T-26
C009	U-27
C101	G-26
C102	H-22
C103	F-18
C104	G-18
C105	H-18
C106	K-23
C107	K-22
C108	L-21
C109	K-19
C110	M-24
C111	P-26
C112	Q-22
C113	Q-22
C114	Q-20
C115	T-20
C201	Y-19
C202	a-23
C203	a-20
C204	a-21
C205	a-18
C206	a-17
C207	c-18
C208	d-17
C209	e-21
C210	f-24
C601	B-28
C602	B-26
C603	D-25
C604	L-15
C605	F-13
C606	J-13
C607	J-11
C608	L-10
C609	L-10
C610	L-8

Circuit Desig.	Location Code
C611	J-2
C612	I-14
C701	T-14
C702	Z-15
C801	P-10
C802	N-8
C803	Q-9
C804	R-9
C805	N-7
C806	N-5
C807	R-8
C808	R-5
C809	S-5
C810	P-2
C811	U-7
C812	V-8
C813	V-7
C814	T-3
C815	X-10
C816	X-5
C817	Y-5
C818	X-3
C819	Z-6
C820	f-5
C821	f-4
C901	V-11
C902	D-19
C903	f-14
C904	g-14
C905	g-12
C906	g-7
C907	h-6
C908	g-3
C909 (NS)	k-26
C910 (NS)	h-24
CR001	J-26
CR002	L-26
CR003	W-30
CR201	U-19
CR202	V-17
CR203	V-19
CR204	V-18
CR205	W-21
CR206	Y-17

Circuit Desig.	Location Code
CR207	Y-23
CR208	b-23
CR209	c-23
CR210	c-23
CR211	d-23
CR212	d-23
CR213	H-33
CR214	W-18
CR601	J-8
CR602	J-5
CR701	P-14
CR702	P-13
CR703	S-13
CR704	Y-13
CR705	e-16
CR801	Q-5
CR802	V-5
CR803	a-2
CR804	b-2
CR901	W-9
CR902	g-9
CR903	h-19
CR904 (NS)	m-23
CR905 (NS)	m-24
DS601	p-30
F601	C-16
J201	b-30
K801	U-6
K901	K-9
P101	e-25
P601	H-31
P602	B-16
P603	K-7
P604	K-4
P605	g-31
P606	k-31
P901	k-1
P902	p-1

TABLE 7-2 (continued)
Component Designations For PC-407

Circuit Desig.	Location Code
Q001	H-25
Q002	R-25
Q003	V-29
Q101	F-19
Q102	H-21
Q103	J-22
Q104	J-21
Q105	K-24
Q106	L-23
Q107	L-21
Q108	M-22
Q109	M-21
Q110	S-23
Q111	S-22
Q112	S-21
Q113	S-20
Q201	L-20
Q202	S-18
Q203	S-17
Q204	T-18
Q205	T-17
Q206	X-19
Q207	X-17
Q208	Y-19
Q209	b-22
Q210	b-20
Q211	d-21
Q212	d-20
Q213	d-19
Q214	f-22
Q215	f-21
Q216	h-22
Q701	P-16
Q702	P-15
Q703	Q-15
Q704	Q-14
Q705	P-12
Q706	Q-12
Q707	X-14
Q708	Z-14
Q709	a-14
Q710	b-15

Circuit Desig.	Location Code
Q801	P-9
Q802	N-6
Q803	P-4
Q804	Q-9
Q805	b-3
Q901	V-10
Q902	e-9
Q903	f-10
R001	H-27
R002	J-27
R003	Q-27
R004	R-27
R005	S-26
R006	S-30
R007	T-30
R008	S-29
R009	U-30
R010	V-29
R011	X-30
R012	Y-29
R013	T-27
R101	H-27
R102	F-25
R103	F-23
R104	F-21
R105	F-18
R106	H-20
R107	G-19
R108	H-18
R109	H-17
R110	T-23
R111	X-26
R112	X-27
R113	Z-26
R114	Z-27
R201	K-17
R202	L-19
R203	L-18
R204	M-18
R205	M-18
R206	N-18
R207	P-18
R208	P-19

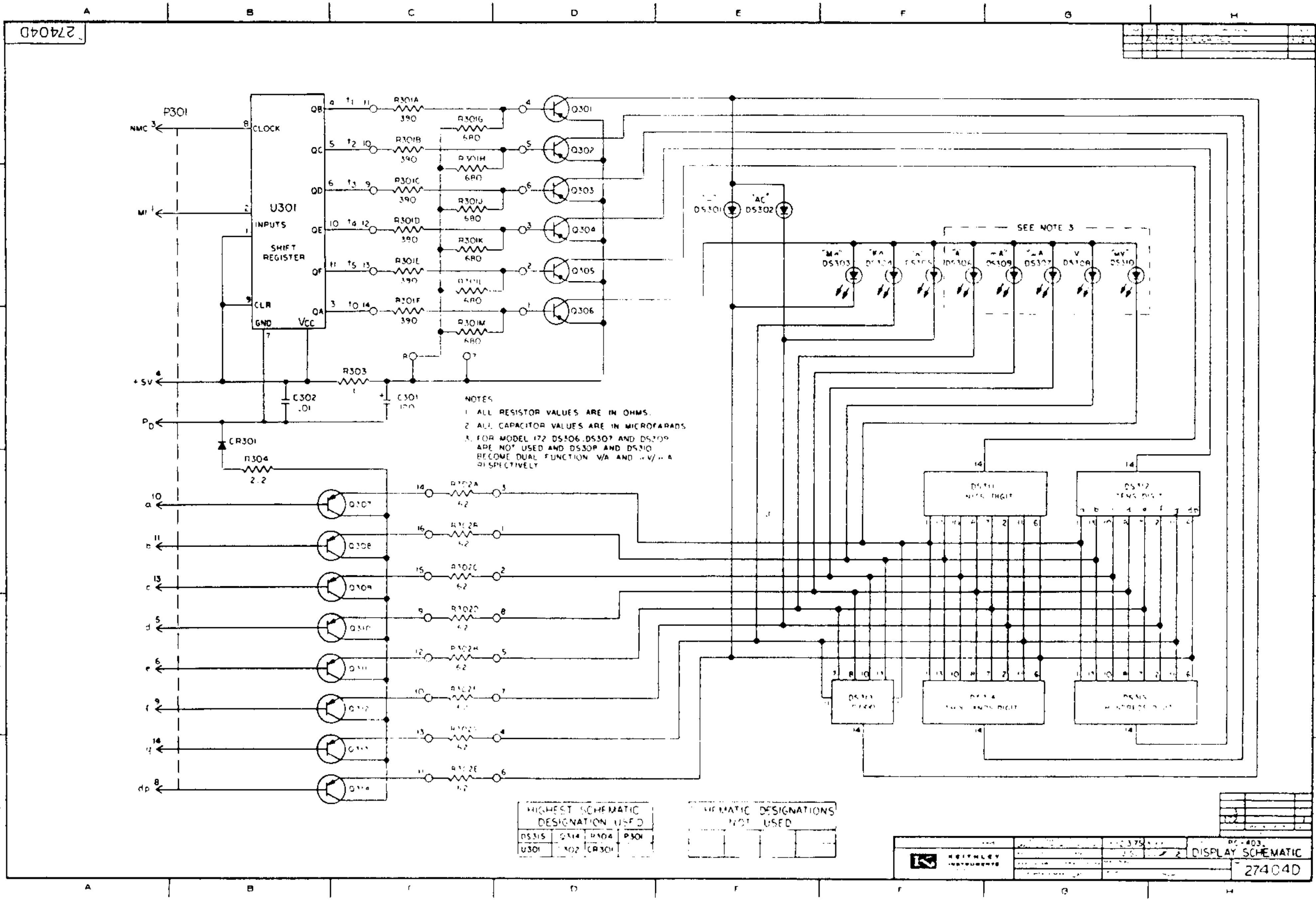
Circuit Desig.	Location Code
R209	R-19
R210	Q-18
R211	U-24
R212	U-21
R213	U-23
R214	U-18
R215	W-24
R216	V-21
R217	V-20
R218	W-18
R219	Y-21
R220	X-18
R221	Z-23
R222	Z-18
R223	b-24
R224	b-22
R225	b-18
R226	d-18
R227 (NS)	d-20
R228	e-17
R229	g-24
R230	g-22
R231	e-28
R601	B-30
R602	B-31
R603	C-30
R604	D-31
R605	E-30
R606	D-27
R607	L-4
R608	L-4
R609	M-4
R610 (NS)	k-28
R611	p-26
R612	M-10
R613	M-9
R701	N-15
R702	P-13
R703	R-13
R704	U-16
R705	V-16
R706	U-15
R707	U-13
R708	V-15
R709	W-14
R710	Y-16

TABLE 7-2 (continued)
Component Designations For PC-407

Circuit Desig.	Location Code
R801	N-10
R802	P-9
R803	S-11
R804	P-6
R805	N-4
R806	Q-4
R807	R-4
R808	R-3
R809	R-2
R810	T-6
R811	T-6
R812	T-5
R813	X-9
R814	Y-8
R815	W-5
R816	V-4
R817	W-2
R818	b-4
R819	Z-2
R820	c-2
R901	U-12
R902	T-11
R903	U-11
R904	T-9
R905	U-10
R906	U-9
R907	NOT USED
R908	NOT USED
R909	X-12
R910	W-11
R911	Y-12
R912	Z-12
R913	a-12
R914	NOT USED
R915	b-8
R916	c-7
R917	d-12
R918	e-12
R919	e-11
R920	e-10
R921	f-12
R922	f-11
R923	g-5
R924	e-18
R925	f-19
R926	f-18

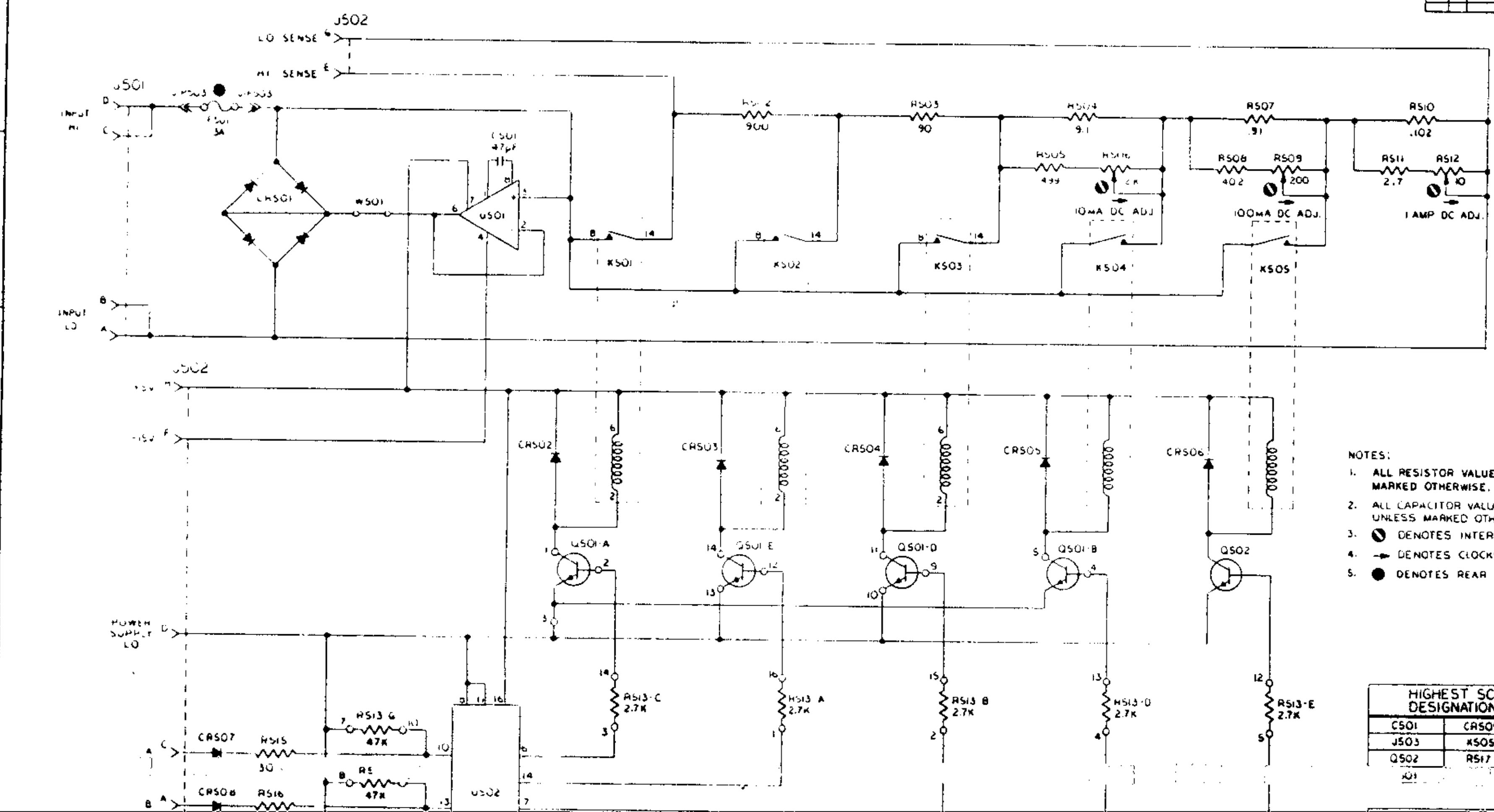
Circuit Desig.	Location Code
R927 (NS)	k-17
R928 (NS)	g-15
R929 (NS)	n-16
R930	p-20
R931	p-20
S601	B-20
T601	D-7
TP101	M-23
TP102	M-24
U001	J-28
U002	N-27
U003	Q-29
U004	U-28
U005	U-26
U101	H-20
U102	P-24
U103	a-26
U201	W-23
U202	X-20
U701	S-15
U702	b-13
U901	d-14
VR001	X-29
VR101	F-26
VR102	G-21
VR201	L-19
VR202	N-18
VR203	Z-23
VR601	B-25
VR602	F-16
VR603	L-13
VR801	Y-9
W201	P-18
W601	D-29
W602	D-29

Circuit Desig.	Location Code
W603	E-28
W604	E-28
W605	D-27
W606	D-27
W607	L-9
W801	C-5
W901	f-19


274040D
P301
NMC
MI
+5V
PD
U301
CLOCK
INPUTS
SHIFT REGISTER
CLR
GND
VCC
QB
QC
QD
QE
QF
QA
R301A 390
R301B 390
R301C 390
R301D 390
R301E 390
R301F 390
R301G 680
R301H 680
R301J 680
R301K 680
R301L 680
R301M 680
Q301
Q302
Q303
Q304
Q305
Q306
R303
C302 .01
C301
CR301
R304 2.2
"AC" DS302
DS301
SEE NOTE 3
"MA" DS303
DS306
DS309
DS308
DS310
Q307
Q308
Q309
Q310
Q311
Q312
Q313
Q314
R302A 62
R302B 62
R302C 62
R302D 62
R302H 62
R302E 62
NOTES
1. ALL RESISTOR VALUES ARE IN OHMS.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. FOR MODEL 172 DS306, DS307 AND DS309 ARE NOT USED AND DS308 AND DS310 BECOME DUAL FUNCTION V/A AND mV/mA RESPECTIVELY.
DS311
DS312
DS313
DS314
DS315
HIGHEST SCHEMATIC DESIGNATION USED
DS315
Q314
R304
P301
U301
C302
CR301
SCHEMATIC DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS
DISPLAY SCHEMATIC
274040D

27478D

FOR MODEL 173



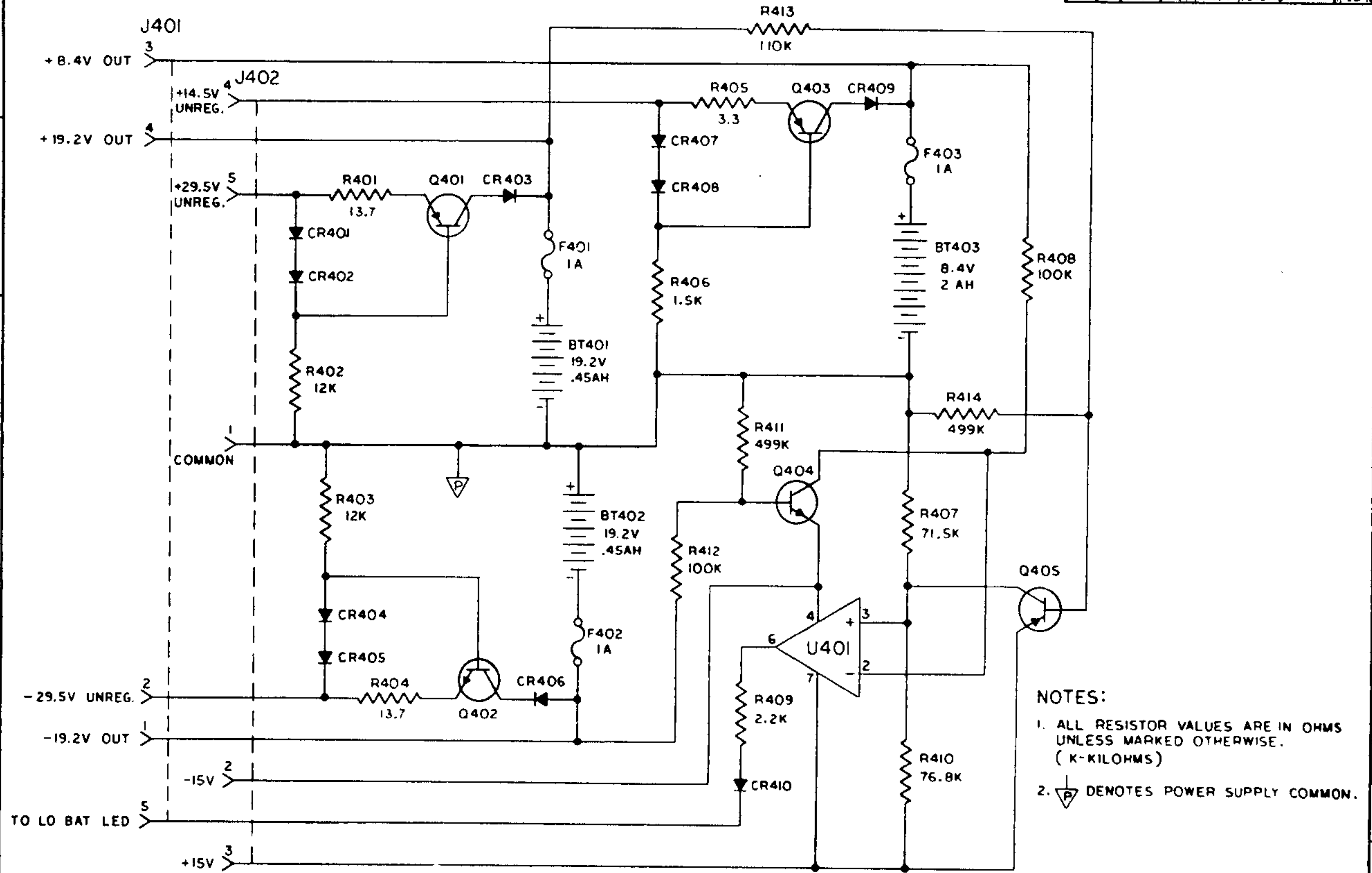
NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3. DENOTES INTERNAL ADJ.
4. DENOTES CLOCKWISE ROTATION.
5. DENOTES REAR PANEL CONTROL.

HIGHEST SCHEMATIC DESIGNATIONS USED		
C501	CR509	F501
J503	K505	P503
Q502	R517	U502
101		

26758C

ZONE	LTR	ECO NO	REVISION	DATE
	A	4996	RELEASED	9-22-75
	B	5293	ADDED Q405, R413 & R414	6-16-76
	C	5451	R401 & R404 WERE 15K	11-23-76



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS)
2. (P) DENOTES POWER SUPPLY COMMON.

HIGHEST SCHEMATIC DESIGNATIONS USED		
BT403	CR410	F403
J402	Q405	R414
U410		

SCHEMATIC DESIGNATIONS NOT USED		

1728		1
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

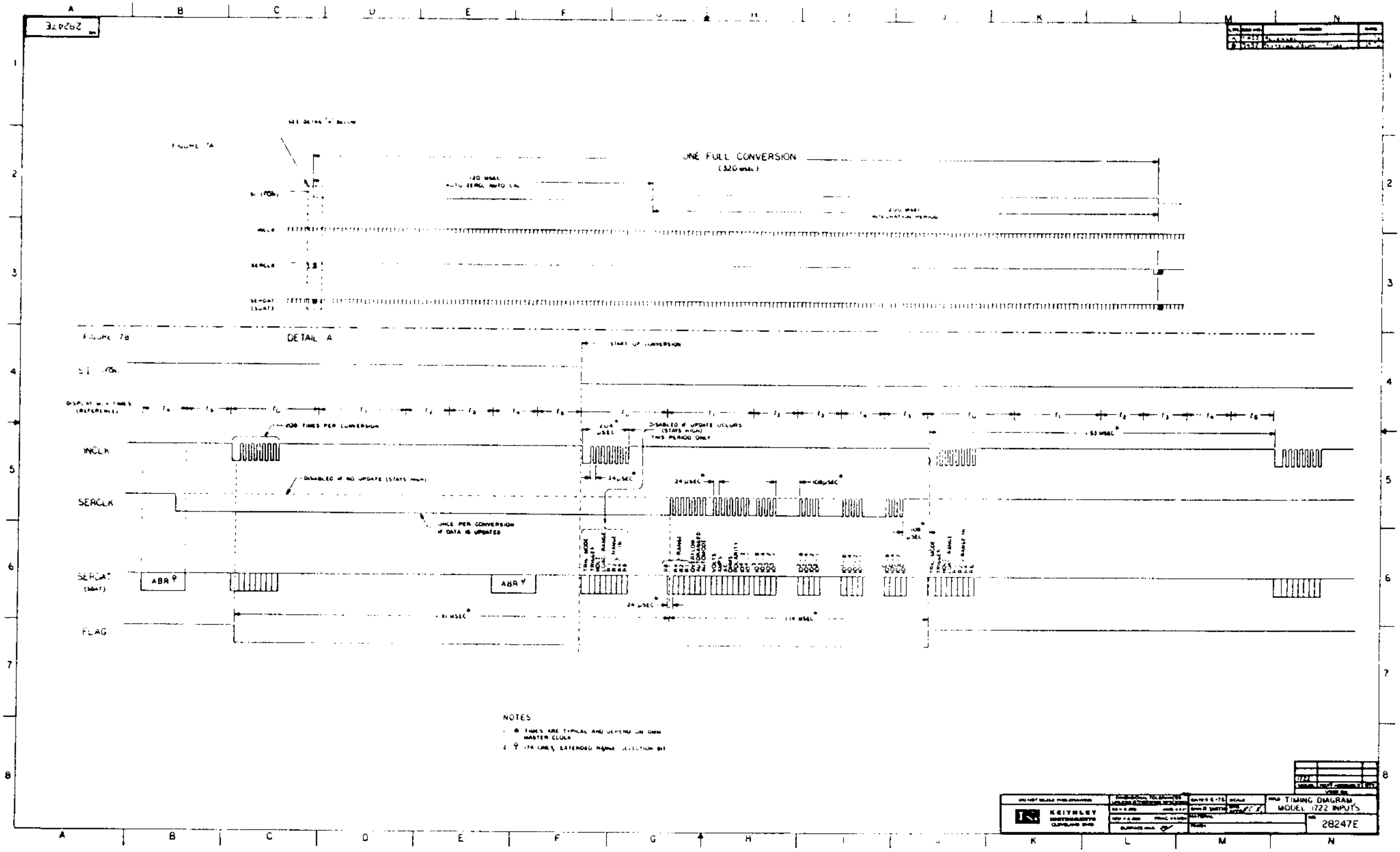
KEITHLEY INSTRUMENTS CLEVELAND OHIO

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ±.015 ANG = ±1°
XXX = ±.005 FRAC = ±1/64
SURFACE MAX

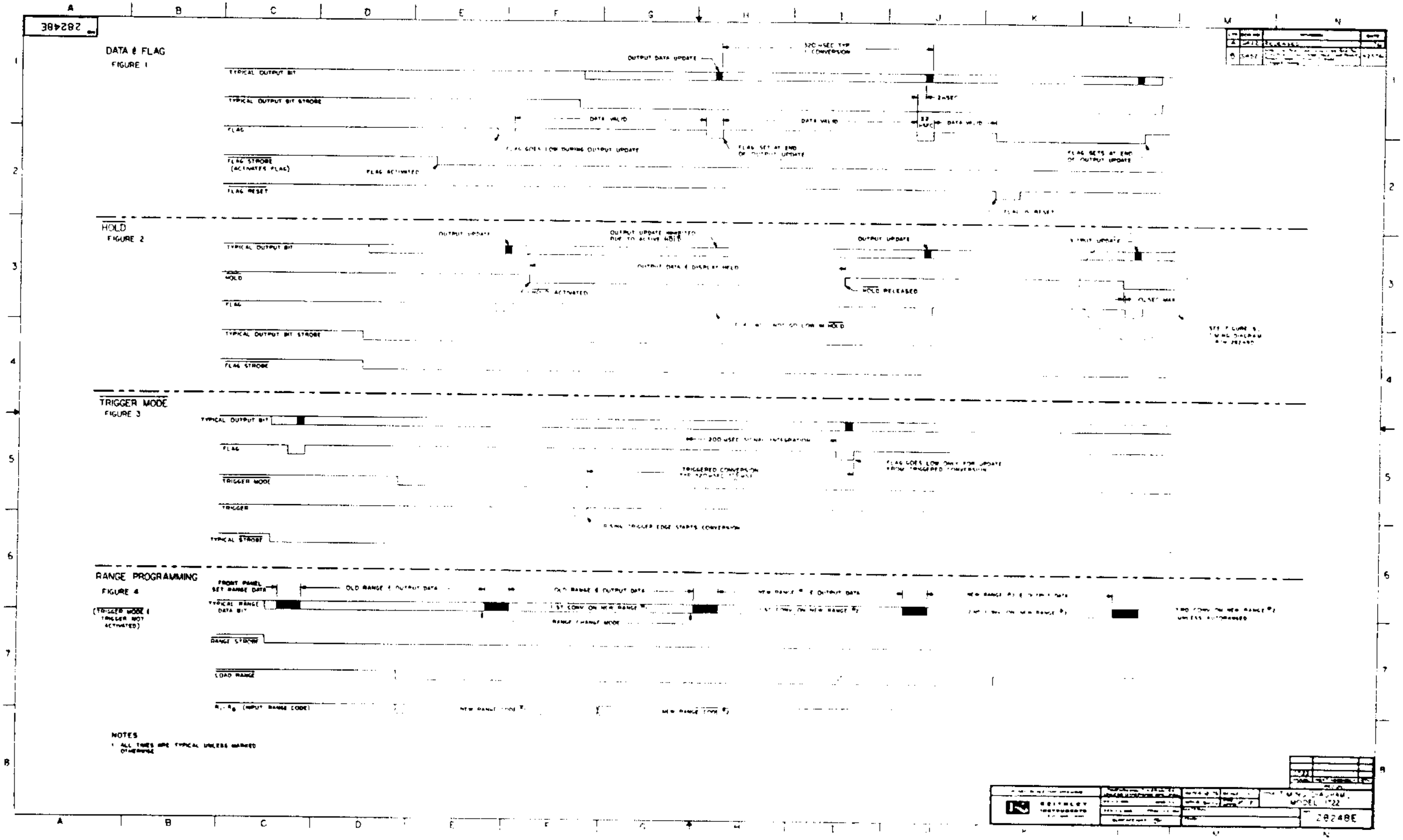
DATE 4-2-75 SCALE ~
DRN R SMITH ENG APPR RCX
MATERIAL
FINISH

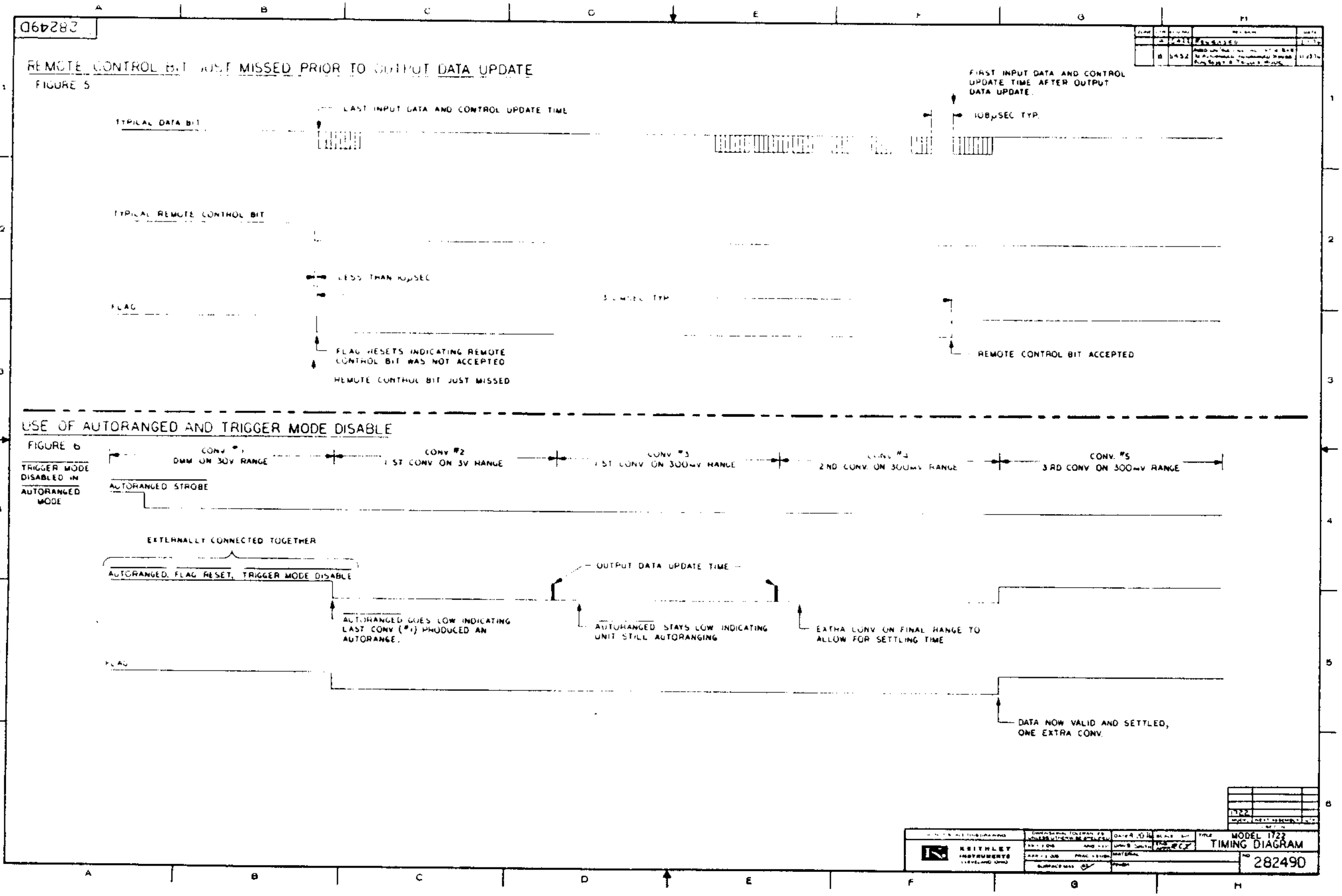
TITLE SCHEMATIC, PC-404, BATTERY PACK

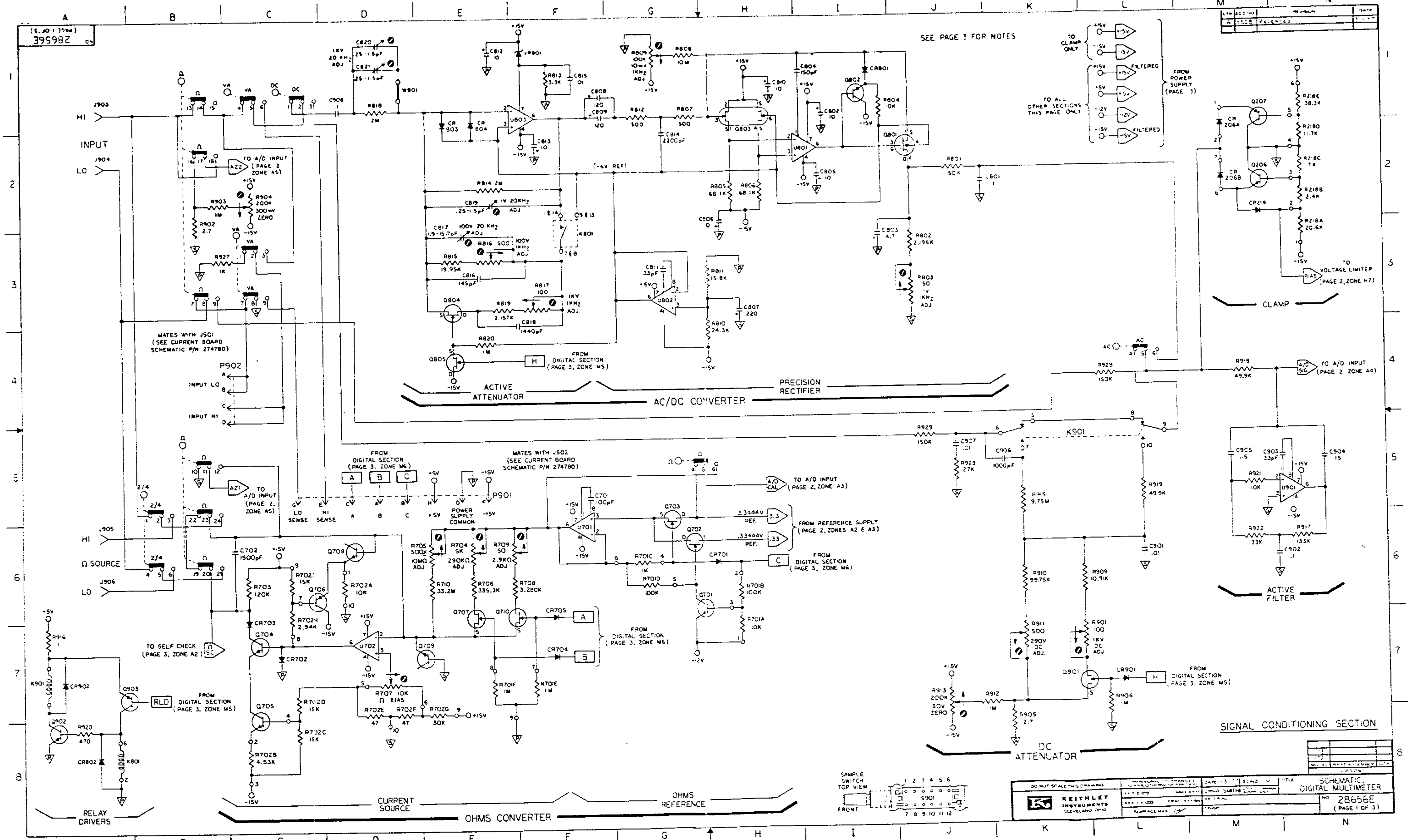
NO 26758C



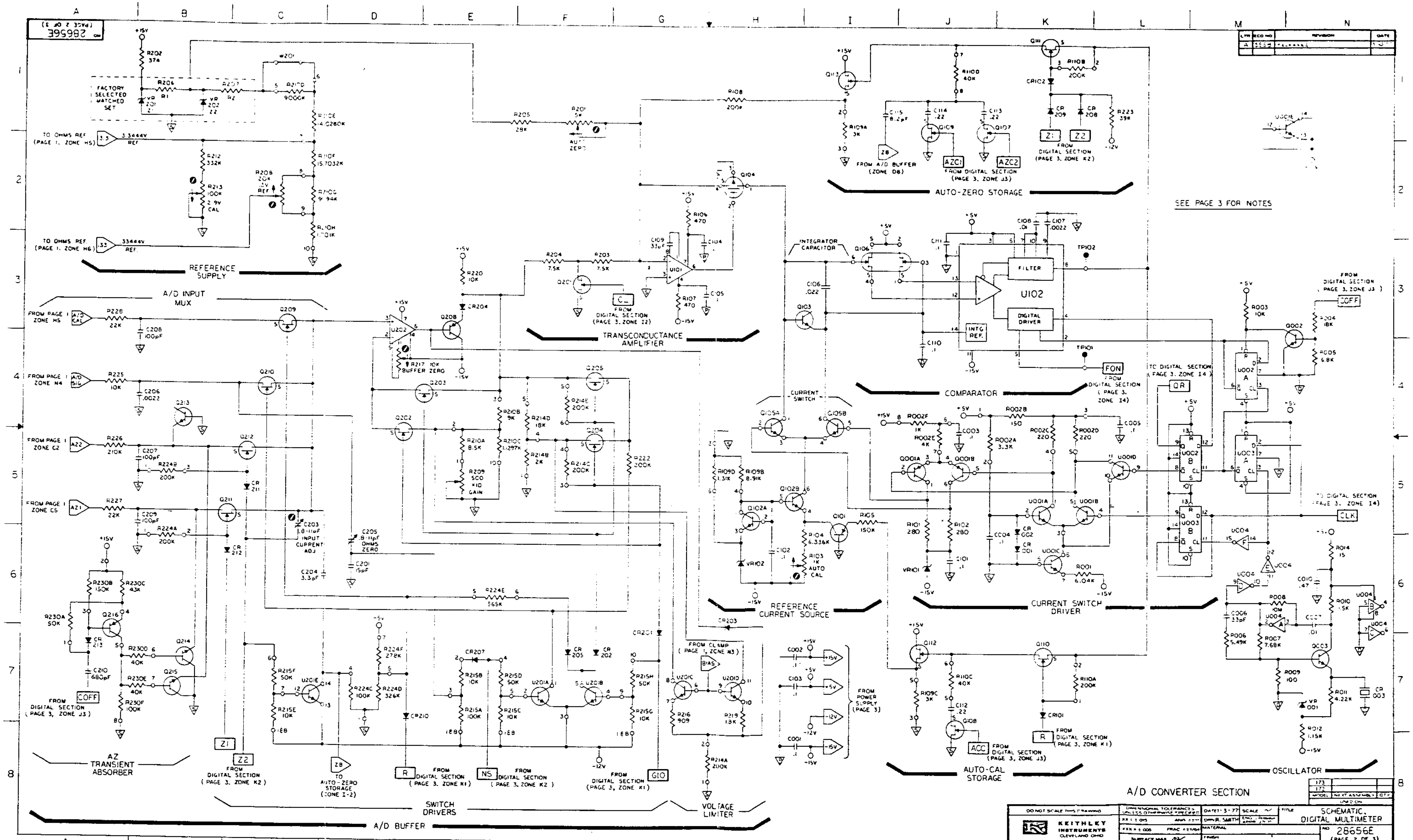
ONE FULL CONVERSION
(320 msec)
120 MSEC
AUTO ZERO, AUTO CAL
200 MSEC
INTEGRATION PERIOD
FIGURE 7A
FIGURE 7B
DETAIL A
START OF CONVERSION
INCLK
SERCLK
SERDAT
(SDAT)
FLAG
ABR
208 TIMES PER CONVERSION
DISABLED IF NO UPDATE (STAYS HIGH)
ONCE PER CONVERSION
IF DATA IS UPDATED
DISABLED IF UPDATE OCCURS
(STAYS HIGH)
THIS PERIOD ONLY
204 μSEC
24 μSEC
108 μSEC
53 MSEC
NOTES
1. * TIMES ARE TYPICAL AND DEPEND ON 6MHz MASTER CLOCK
2. ♀ 174 ONLY, EXTENDED RANGE SELECTION BIT
KEITHLEY
INSTRUMENTS
CLEVELAND OHIO
TIMING DIAGRAM
MODEL 1722 INPUTS
28247E


28248E
DATA & FLAG
FIGURE 1
TYPICAL OUTPUT BIT
TYPICAL OUTPUT BIT STROBE
FLAG
FLAG STROBE (ACTIVATES FLAG)
FLAG RESET
OUTPUT DATA UPDATE
320 uSEC TYP
DATA VALID
FLAG GOES LOW DURING OUTPUT UPDATE
FLAG SET AT END OF OUTPUT UPDATE
FLAG ACTIVATED
FLAG SETS AT END OF OUTPUT UPDATE
FLAG IS RESET
HOLD
FIGURE 2
TYPICAL OUTPUT BIT
HOLD
FLAG
TYPICAL OUTPUT BIT STROBE
FLAG STROBE
OUTPUT UPDATE
OUTPUT UPDATE INHIBITED DUE TO ACTIVE HOLD
OUTPUT DATA & DISPLAY HELD
HOLD ACTIVATED
HOLD RELEASED
TRIGGER MODE
FIGURE 3
TYPICAL OUTPUT BIT
FLAG
TRIGGER MODE
TRIGGER
TYPICAL STROBE
200 uSEC SIGNAL INTEGRATION
TRIGGERED CONVERSION
FLAG GOES LOW ONLY FOR UPDATE FROM TRIGGERED CONVERSION
RISING TRIGGER EDGE STARTS CONVERSION
RANGE PROGRAMMING
FIGURE 4
(TRIGGER MODE & TRIGGER NOT ACTIVATED)
FRONT PANEL SET RANGE DATA
TYPICAL RANGE DATA BIT
RANGE STROBE
LOAD RANGE
OLD RANGE & OUTPUT DATA
1ST CONV ON NEW RANGE
RANGE CHANGE MODE
NEW RANGE CODE
NOTES
1. ALL TIMES ARE TYPICAL UNLESS MARKED OTHERWISE
TIMING DIAGRAM
MODEL 1722
KEITHLEY INSTRUMENTS
28248E

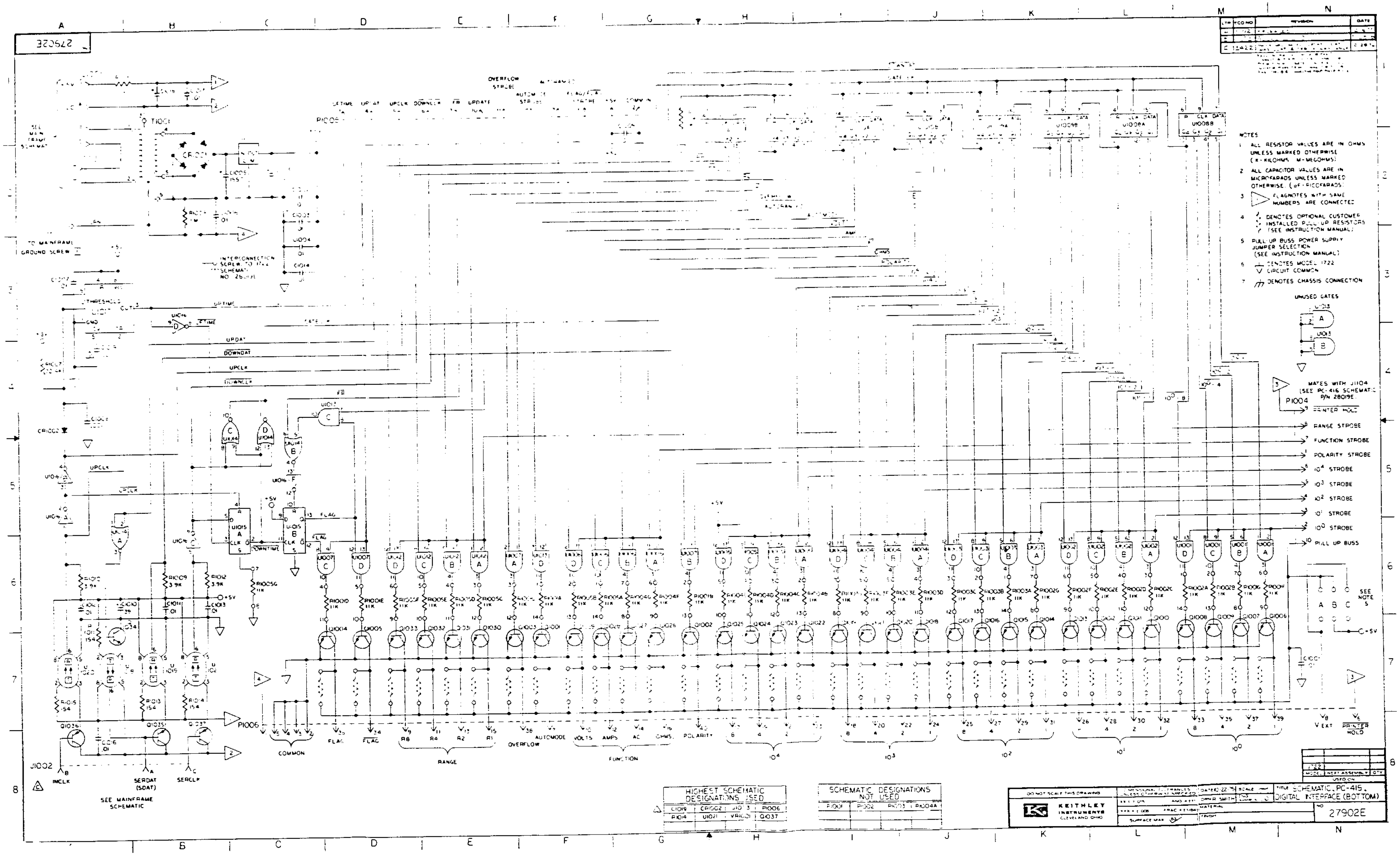

282490
REMOTE CONTROL BIT JUST MISSED PRIOR TO OUTPUT DATA UPDATE
FIGURE 5
TYPICAL DATA BIT
LAST INPUT DATA AND CONTROL UPDATE TIME
FIRST INPUT DATA AND CONTROL UPDATE TIME AFTER OUTPUT DATA UPDATE.
108μSEC TYP.
TYPICAL REMOTE CONTROL BIT
LESS THAN 10μSEC
FLAG
FLAG RESETS INDICATING REMOTE CONTROL BIT WAS NOT ACCEPTED
REMOTE CONTROL BIT JUST MISSED
REMOTE CONTROL BIT ACCEPTED
USE OF AUTORANGED AND TRIGGER MODE DISABLE
FIGURE 6
TRIGGER MODE DISABLED IN AUTORANGED MODE
CONV #1 DMM ON 30V RANGE
CONV #2 1 ST CONV ON 3V RANGE
CONV #3 1 ST CONV ON 300mV RANGE
CONV #4 2 ND CONV ON 300mV RANGE
CONV #5 3 RD CONV ON 300mV RANGE
AUTORANGED STROBE
EXTERNALLY CONNECTED TOGETHER
AUTORANGED, FLAG RESET, TRIGGER MODE DISABLE
OUTPUT DATA UPDATE TIME
AUTORANGED GOES LOW INDICATING LAST CONV (#1) PRODUCED AN AUTORANGE.
AUTORANGED STAYS LOW INDICATING UNIT STILL AUTORANGING
EXTRA CONV ON FINAL RANGE TO ALLOW FOR SETTLING TIME
FLAG
DATA NOW VALID AND SETTLED, ONE EXTRA CONV.
KEITHLEY INSTRUMENTS CLEVELAND OHIO
MODEL 1722
TIMING DIAGRAM
282490

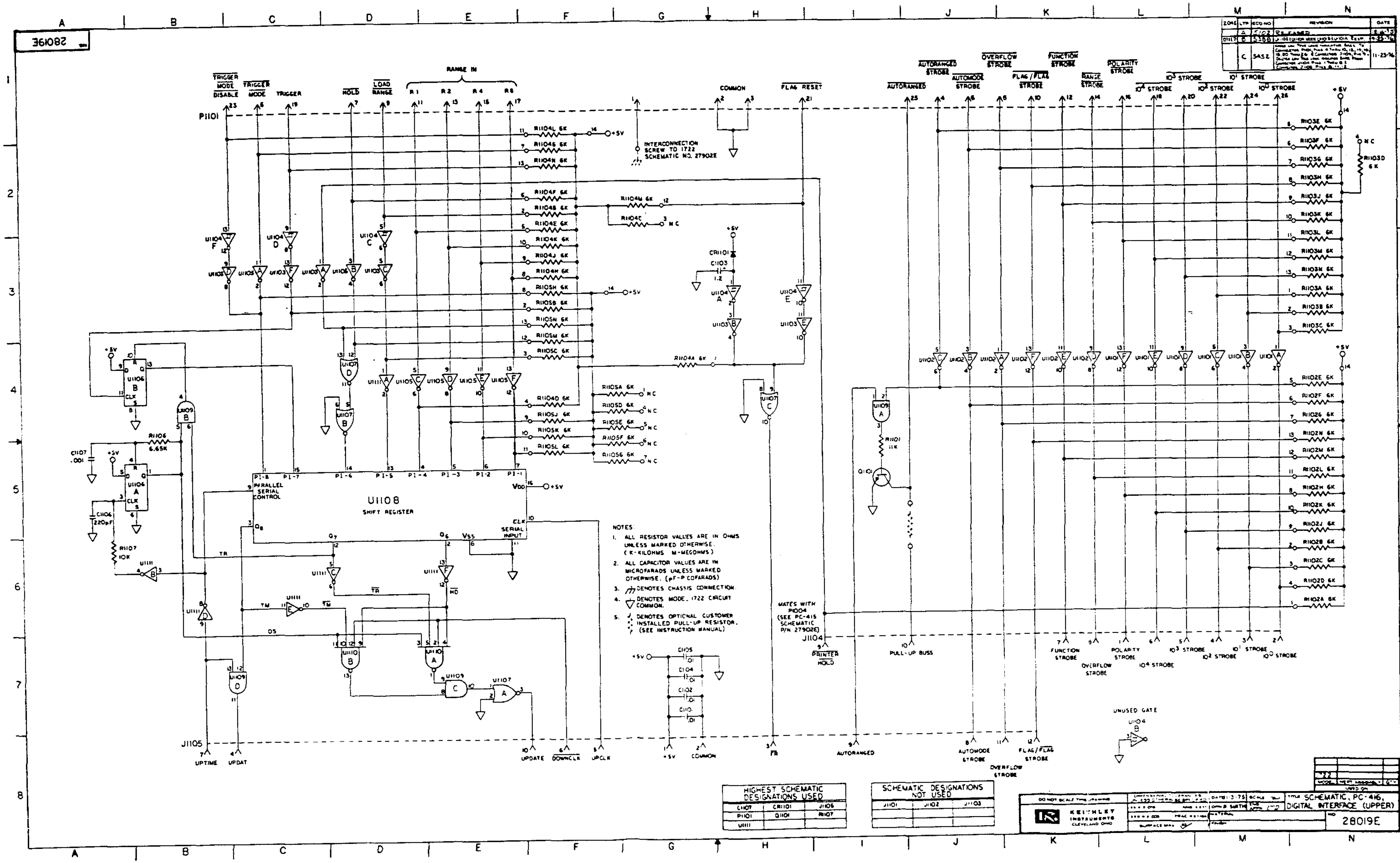


SEE PAGE 3 FOR NOTES
INPUT
HI
LO
Ω SOURCE
TO A/D INPUT (PAGE 2, ZONE A5)
MATES WITH J501 (SEE CURRENT BOARD SCHEMATIC P/N 27478D)
P902
INPUT LO
INPUT HI
ACTIVE ATTENUATOR
PRECISION RECTIFIER
AC/DC CONVERTER
FROM DIGITAL SECTION (PAGE 3, ZONE M5)
TO CLAMP ONLY
TO ALL OTHER SECTIONS THIS PAGE ONLY
FILTERED
FROM POWER SUPPLY (PAGE 3)
TO VOLTAGE LIMITER (PAGE 2, ZONE H7)
CLAMP
TO A/D INPUT (PAGE 2, ZONE A4)
K901
ACTIVE FILTER
MATES WITH J502 (SEE CURRENT BOARD SCHEMATIC P/N 27478D)
P901
LO SENSE
HI SENSE
POWER SUPPLY COMMON
TO A/D INPUT (PAGE 2, ZONE A3)
FROM REFERENCE SUPPLY (PAGE 2, ZONES A2 & A3)
FROM DIGITAL SECTION (PAGE 3, ZONE M6)
TO SELF CHECK (PAGE 3, ZONE A2)
FROM DIGITAL SECTION (PAGE 3, ZONE M5)
RELAY DRIVERS
CURRENT SOURCE
OHMS REFERENCE
OHMS CONVERTER
SAMPLE SWITCH TOP VIEW
FRONT
DC ATTENUATOR
SIGNAL CONDITIONING SECTION
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, DIGITAL MULTIMETER
28656E
(PAGE 1 OF 3)

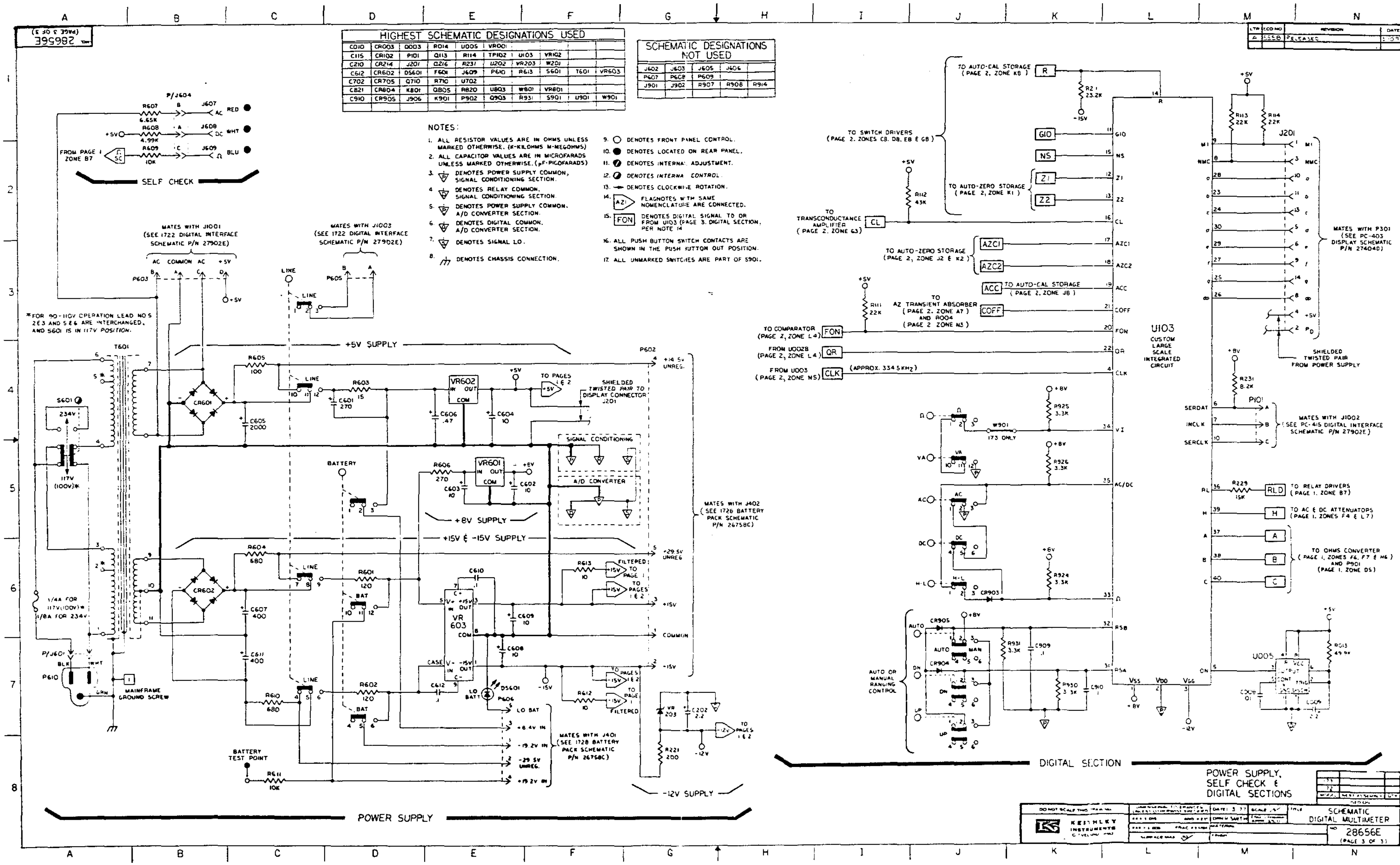


REFERENCE SUPPLY
A/D INPUT MUX
TRANSCONDUCTANCE AMPLIFIER
AUTO-ZERO STORAGE
COMPARATOR
CURRENT SWITCH
REFERENCE CURRENT SOURCE
CURRENT SWITCH DRIVER
AUTO-CAL STORAGE
OSCILLATOR
AZ TRANSIENT ABSORBER
SWITCH DRIVERS
VOLTAGE LIMITER
A/D BUFFER
INTEGRATOR CAPACITOR
FACTORY SELECTED MATCHED SET
SEE PAGE 3 FOR NOTES
FROM POWER SUPPLY (PAGE 3)
A/D CONVERTER SECTION
KEITHLEY INSTRUMENTS CLEVELAND OHIO
SCHEMATIC, DIGITAL MULTIMETER
28656E
(PAGE 2 OF 3)


NOTES
1 ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE (K = KILOHMS M = MEGOHMS)
2 ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF = PICOFARADS)
3 FLAGNOTES WITH SAME NUMBERS ARE CONNECTED
4 DENOTES OPTIONAL CUSTOMER INSTALLED PULL-UP RESISTORS (SEE INSTRUCTION MANUAL)
5 PULL-UP BUSS POWER SUPPLY JUMPER SELECTION (SEE INSTRUCTION MANUAL)
6 DENOTES MODEL 1722 CIRCUIT COMMON
7 DENOTES CHASSIS CONNECTION
UNUSED GATES
MATES WITH J1104 (SEE PC-416 SCHEMATIC P/N 28019E)
P1004
PRINTER HOLD
RANGE STROBE
FUNCTION STROBE
POLARITY STROBE
10⁴ STROBE
10³ STROBE
10² STROBE
10¹ STROBE
10⁰ STROBE
PULL UP BUSS
COMMON
FLAG
RANGE
OVERFLOW
AUTOMODE
FUNCTION
VOLTS
AMPS
AC
OHMS
POLARITY
SEE NOTE 5
J1002
INCLK
SERDAT (SDAT)
SERCLK
SEE MAINFRAME SCHEMATIC
TO MAINFRAME GROUND SCREW
INTERCONNECTION SCREW TO 1722 SCHEMATIC NO 28032E
HIGHEST SCHEMATIC DESIGNATIONS USED
C1019 CR1002 J1013 P1006
R1014 U1021 VR1001 Q1037
SCHEMATIC DESIGNATIONS NOT USED
P1001 P1002 P1003 P1004A
DO NOT SCALE THIS DRAWING
KEITHLEY INSTRUMENTS CLEVELAND OHIO
DATE 10-22-75
DRN R. SMITH
TITLE SCHEMATIC, PC-415, DIGITAL INTERFACE (BOTTOM)
NO 27902E
MODEL 1722
NEXT ASSEMBLY
USED ON



361082
SCHEMATIC, PC-416, DIGITAL INTERFACE (UPPER)
28019E
KEITHLEY INSTRUMENTS CLEVELAND OHIO
DO NOT SCALE THIS DRAWING
U1108 SHIFT REGISTER
PARALLEL SERIAL CONTROL
CLK SERIAL INPUT
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-P COFARADS)
3. DENOTES CHASSIS CONNECTION
4. DENOTES MODEL 1722 CIRCUIT COMMON.
5. DENOTES OPTIONAL CUSTOMER INSTALLED PULL-UP RESISTOR. (SEE INSTRUCTION MANUAL)
HIGHEST SCHEMATIC DESIGNATIONS USED
C1107 CR1101 J1106
P1101 Q1101 R1107
U1111
SCHEMATIC DESIGNATIONS NOT USED
J1101 J1102 J1103
INTERCONNECTION SCREW TO 1722 SCHEMATIC NO. 27902E
MATES WITH P1004 (SEE PC-415 SCHEMATIC P/N 27902E)
P1101
J1104
J1105
TRIGGER MODE DISABLE
TRIGGER MODE
TRIGGER
HOLD
LOAD RANGE
RANGE IN
R1 R2 R4 R8
COMMON
FLAG RESET
AUTORANGED
AUTORANGED STROBE
AUTOMODE STROBE
OVERFLOW STROBE
FLAG/FLAG STROBE
FUNCTION STROBE
RANGE STROBE
POLARITY STROBE
10⁴ STROBE
10³ STROBE
10² STROBE
10¹ STROBE
10⁰ STROBE
PRINTER HOLD
PULL-UP BUSS
UPTIME
UPDAT
UPDATE
DOWNCLK
UPCLK
UNUSED GATE
U1104 B



HIGHEST SCHEMATIC DESIGNATIONS USED

C010	CR003	Q003	R014	U005	VR001				
C115	CR102	P101	Q113	R114	TP102	U103	VR102		
C210	CR214	J201	Q216	R231	U202	VR203	W201		
C612	CR602	DS601	F601	J609	P610	R613	S601	T601	VR603
C702	CR705	Q710	R710	U702					
C821	CR804	K801	Q805	R820	U803	W801	VR801		
C910	CR905	J906	K901	P902	Q903	R931	S901	U901	W901

SCHEMATIC DESIGNATIONS NOT USED

J602	J603	J605	J606	
P607	P608	P609		
J901	J902	R907	R908	R914

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (pF-PICOFARADS)
3. DENOTES POWER SUPPLY COMMON, SIGNAL CONDITIONING SECTION.
4. DENOTES RELAY COMMON, SIGNAL CONDITIONING SECTION.
5. DENOTES POWER SUPPLY COMMON, A/D CONVERTER SECTION.
6. DENOTES DIGITAL COMMON, A/D CONVERTER SECTION.
7. DENOTES SIGNAL LO.
8. DENOTES CHASSIS CONNECTION.
9. ○ DENOTES FRONT PANEL CONTROL.
10. ● DENOTES LOCATED ON REAR PANEL.
11. DENOTES INTERNAL ADJUSTMENT.
12. DENOTES INTERNAL CONTROL.
13. DENOTES CLOCKWISE ROTATION.
14. AZ1 FLAGNOTES WITH SAME NOMENCLATURE ARE CONNECTED.
15. FON DENOTES DIGITAL SIGNAL TO OR FROM U103 (PAGE 3, DIGITAL SECTION, PER NOTE 14
16. ALL PUSH BUTTON SWITCH CONTACTS ARE SHOWN IN THE PUSH BUTTON OUT POSITION.
17. ALL UNMARKED SWITCHES ARE PART OF S901.

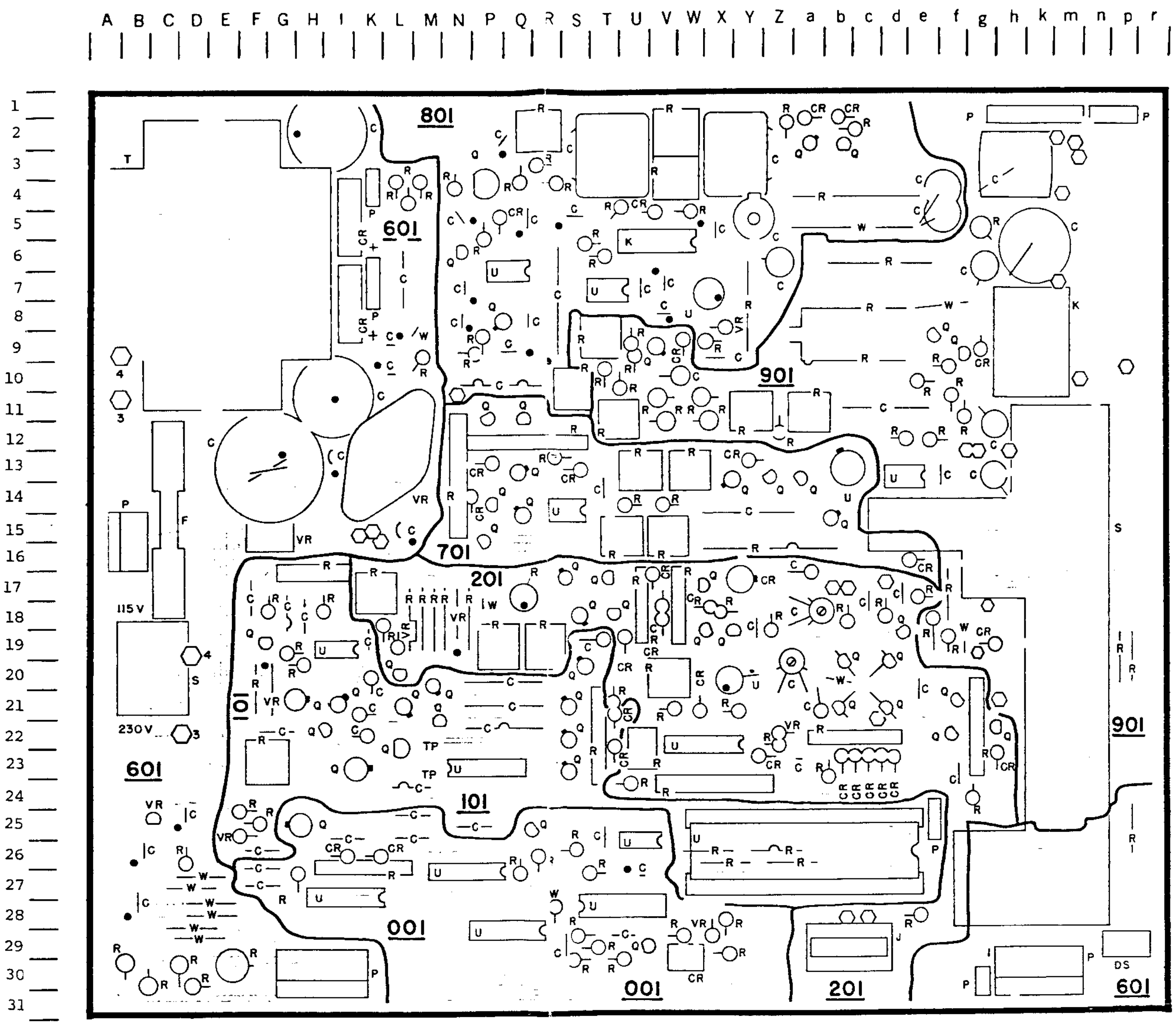


FIGURE 43. Component Layout, PC-407 (See Table 7-2).

REV D